Reg. U. S. Pat. Off

OFFICERS

Board of Directors

President
Arthur W. Carpenter

Vice-Presidents
T. A. Boyd — Richard L. Templin

Members of Board

Term ending 1947	*Term ending 1948*
W. C. Hanna	J. R. Freeman, Jr.
L. B. Jones	L. J. Markwardt
J. T. MacKenzie	C. H. Rose
J. G. Morrow	L. P. Spalding
Sam Tour	W. A. Zinzow

Term ending 1949
A. G. Ashcroft
A. T. Chameroy
James H. Foote
F. E. Richart
L. H. Winkler

Past-Presidents
Dean Harvey — P. H. Bates
J. R. Townsend

Executive Secretary
C. L. Warwick

COMMITTEE ON PAPERS AND PUBLICATIONS

This committee has authority in all matters affecting the acceptance, rejection, editing and publication of papers, committee reports, and discussions. The committee also acts in an advisory capacity to the Board of Directors in publication matters in general.

C. L. Warwick, *Chairman*

H. C. Cross — G. R. Gohn
A. G. H. Dietz — P. G. McVetty
Wm. Howlett Gardner — H. K. Nason
J. C. Geniesse — H. S. Rawdon
K. B. Woods

Correspondent Members from Pacific Coast District
F. J. Converse — R. E. Davis

The Society is not responsible, as a body, for the statements and opinions advanced in this publication.

ASTM Bulletin, May, 1947. Published six times a year, January, March, May, August, October, and December, by the American Society for Testing Materials. Publication Office—20th and Northampton Sts., Easton, Pa. Editorial and advertising offices at the headquarters of the Society, 1916 Race St., Philadelphia 3, Pa. Subscription $2.00 a year in United States and possessions, $2.25 in Canada, $2.50 in foreign countries. Single Copies—50 cents. Number 146. Entered as second class matter April 8, 1940, at the post office at Easton, Pa., under the act of March 3, 1879.

Copyrighted, 1947, by the American Society for Testing Materials.

ASTM BULLETIN

Published by
AMERICAN SOCIETY for
TESTING MATERIALS

This Issue Contains

Extensive Technical Program Including Special Features at A.S.T.M. Fiftieth Annual Meeting—Atlantic City—June 16–20 5–9

Review of A.S.T.M. Research Activities 30–42

Provisional Program for the Fiftieth Annual Meeting 43–52

Science Advancing—The Future of Testing, *by E. U. Condon* 53

Progress in Chemical Industry Through Research and Standardization, *by Arthur W. Carpenter* 58

Reproducibility of the Single-Blow Charpy Notched-Bar Test, *by N. A. Kahn and E. A. Imbembo* 66

Determining Consistency on Small Samples of Lubricating Grease, *by R. F. McKibben* 74

Report on Correlation of Laboratory and Service Abrasion Tests of Rubber Tire Treads, *prepared by A. E. Juve, J. H. Fielding, and F. L. Graves on behalf of Section of Subcommittee XIV on Abrasion Tests for Rubber, of A.S.T.M. Committee D-11 on Rubber and Rubber-Like Materials* 77

Ignition Temperatures of Rigid Plastics, *by E. M. Schoenborn and D. S. Weaver, Jr.* 80

Method for the Determination of Water in Tetrachloroethane, Hexachloroethane, and Chlorinated Paraffin, *by L. Wilson Greene* 87

Discussion of paper on "Lubricants for Synchronous Unit Bearings" 89

The Interfacial Tension Test and Its Significance in Appraising Performance of an Insulating Oil, *by G. W. Gerell;* Steam-Emulsion Number as an Index of Transformer Oil Serviceability, by *M. D. Baker;* and Application of the Interfacial Tension Test in Grading Oil in Transformers Relative to Serviceability, *by E. F. Walsh* 90

NEWS ABOUT THE SOCIETY AND ITS COMMITTEES:

Notes on Publications 9, 10

A.S.T.M. Technical Publications Series 11, 12

Actions on Standards 12

Significance of Numerical Limits in Specifications 13

District Activities and Notes 15–19
Rochester, San Francisco, Los Angeles, Pittsburgh and New York

Technical Committee Activities 19–21

Errata in Book of Standards 24

New Members, Personals, Necrology 25–28

MISCELLANEOUS TECHNICAL NOTES AND NEWS:

Membership Form 23, 24

Book Reviews: The Metallurgy of Steel; Arc-Welded Structures; The New Fibers; British Petroleum Publications; Contributions to Soil Mechanics 22, 23

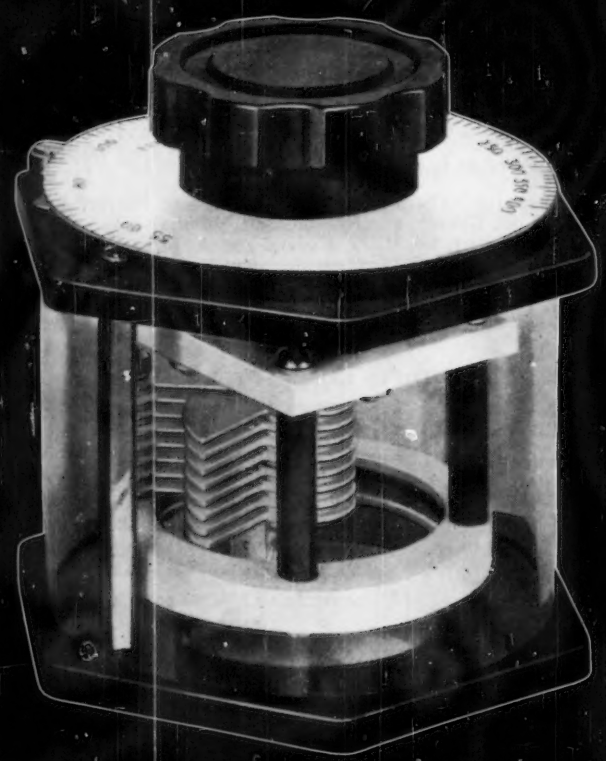
Index to Advertisers 100

MAY—1947

No. 146

WAVEMETERS
0.5—150 Mc
55—400 Mc
IN STOCK!

TYPE 566-A — 0.5 to 150 Mc



TYPE 758-A — 55 to 400 Mc

● To meet an insistent demand, we have concentrated some of our production facilities on these two popular wavemeters and have managed to accumulate a moderate stock of each.

Both are of the well-known absorption type with accuracies sufficient for a wide variety of routine frequency checks on the ranges of coils, oscillators, receivers, transmitters, etc.

The Type 566-A Wavemeter consists of a variable air condenser, five plug-in coils and an incandescent lamp for resonance indication. The Type 758-A Wavemeter covers its entire frequency range with a single-turn loop the inductance of which is varied simultaneously with the capacitance. An incandescent lamp is used for resonance indication. For low power uses (less than about 2 watts), resonance indication is obtained by the reaction of the wavemeters on the plate or grid currents of the oscillator.

These wavemeters are compact, rugged, inexpensive and direct reading in terms of our primary standard of frequency.

TYPE 566-A WAVEMETER

FREQUENCY RANGE: 0.5 to 150 Mc
COILS: Five plug-in type, all supplied. When not in use coils can be plugged into a rack on side of the instrument case
DIAL CALIBRATION: Direct reading in frequency
ACCURACY: ±2%, 0.5 to 16 Mc; ±3%, 16 Mc to 150 Mc
RESONANCE INDICATOR: Incandescent lamp
ACCESSORIES SUPPLIED: Two spare indicator lamps
DIMENSIONS: 4¾ x 5⅞ x 5¾ inches, over-all
WEIGHT: 3 pounds
PRICE: Type 566-A WAVEMETER — $60.00

TYPE 758-A WAVEMETER

FREQUENCY RANGE: 55 to 400 Mc
COILS: A single turn loop; inductance and capacitance are varied simultaneously
DIAL CALIBRATION: Direct reading in frequency
ACCURACY: ±2%
RESONANCE INDICATOR: Incandescent lamp
TEMPERATURE AND HUMIDITY: Over ranges normally encountered, accuracy is independent of both
DIMENSIONS: 5 x 5 x 4¾ inches, over-all
WEIGHT: 1 pound, 12 ounces
PRICE: Type 758-A WAVEMETER — $35.00

ORDER NOW—DELIVERY PROBABLY FROM STOCK

GENERAL RADIO COMPANY
Cambridge 39, Massachusetts

90 West St., New York 6 | 920 S. Michigan Ave., Chicago 5 | 950 N. Highland Ave., Los Angeles 38

ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering, and Standardization of Specifications and Methods of Testing"

TELEPHONE—Rittenhouse 6-5315

R. E. Hess, Editor
R. J. Painter, Associate Editor

CABLE ADDRESS—TESTING

Number 146 May 1947

Extensive Technical Program Including Special Features at A.S.T.M. 50th Annual Meeting

Some Twenty Technical Sessions, Numerous Committee Meetings, and Other Events Will Make Full Week

A VERY FULL week is in store for the hundreds of members of the Society who will be attending the 50th A.S.T.M. Annual Meeting in Atlantic City during the week beginning June 16. Some 20 technical sessions are scheduled, there will be several score meetings of technical committees, with a dinner scheduled for Wednesday evening June 18, featuring the President's address and a guest speaker. There will be events under way morning, afternoon, and evening of each of the days except the last day, Friday June 20, when the closing sessions are scheduled for the afternoon.

50TH ANNUAL MEETING

This will be the Society's 50th Annual Meeting, the first having been held in 1898 in Philadelphia under the auspices of the American Section of the International Association for Testing Materials. It is interesting to note that the first Annual Meeting held during the year of the Society's incorporation in 1902 was at Atlantic City, and since then 30 of the annual meetings have taken place in Atlantic City. Thus it can be seen that this location is a favorite one, and a great many of the members, particularly in recent years, have combined some of their vacation plans with the meeting.

ANNUAL DINNER

The Philadelphia District Council is sponsoring arrangements for the Annual Dinner to be held on Wednesday night June 18 to feature the annual address of the retiring President, Arthur W. Carpenter. An outstanding guest speaker will join him in the program. President Carpenter will dwell briefly on the 50 years of A.S.T M. progress, but will stress the future outlook and indicate the important relations of research not only in the A.S.T.M. planning but for all industry concerned with materials.

He has been devoting much time to the planning of his address since its presentation at the 50th Annual Meeting will make it of particular significance. An interesting writer and speaker, Mr. Carpenter will incorporate ideas based upon many years of close contact with research and standardization problems.

MARBURG LECTURE

The growing importance and use of materials in combination which composites take advantage of certain of the attributes of each material and provide enhanced properties which are not available through any one individual material, led the Marburg Lecture Committee headed by Past-President J. R. Townsend, to select the topic of the Lecture in this general field. Consequently, they concluded that a discussion on engineering laminates and their wide-spread application, particularly in constructional problems, would be most appropriate. It is gratifying to note that Professor W. C. Voss, an authority in this field, has accepted the invitation to present this lecture. (See other details in this BULLETIN, page 8.)

PREPRINTS OF REPORTS AND PAPERS

Each member in good standing received early in May a Preprint Request Blank which he could mark and return to A.S.T.M. Headquarters, thus making known his desire to have certain papers or reports that would be preprinted. This material probably will be mailed in three installments, the final one just before or during the Annual Meeting. Members attending the meeting can of course obtain, as they register, copies of preprinted

Provisional Program for Meeting

The provisional program for the Annual Meeting which includes an outline of each session with synopses of many of the papers is published in this BULLETIN. See pages 43–52.

papers and reports, or abstracts of items that it was not possible to preprint.

Committee Meetings

It is expected there will be two or three hundred meetings during the five days of the Annual Meeting. Complete information with respect to these meetings will be available to members at the time of registration. In the meantime each of the technical committees meeting is sending out notices and schedules to the individual members.

From the advance outline of sessions which went forward to the members during the week of April 14, it is possible to determine the approximate times when committee meetings are to be held and this information should enable the members to make their hotel reservations.

Technical Sessions—Reports Segregated

Symposiums and sessions will be held on the following:

Load Tests of Bearing Capacity of Soils	Synthetic Lubricants
Measurement of Entrained Air in Concrete	Electrodeposited Coatings
Soils	Rubber Testing
Insulating Oil	Identifying Water-Formed Deposits.
	Fatigue

In addition to the sessions noted above, there will be several others in which technical papers relating to specific fields will be presented.

Hotel Rooms and Preprints—Handle Promptly

Each member and committee member should long since have sent in his reservation for hotel accommodations, but if you have not done this, early action is recommended.

Likewise, it is a distinct convenience for Headquarters to have as soon as possible the Preprint Request Blank (distributed to all members early in May). Mark the blank clearly and return to Philadelphia at your earliest convenience.

Details are given in the Provisional Program published elsewhere in this Bulletin. In an effort to streamline the program and keep the technical discussion and the actual business sessions of the meeting distinct, the plan used in 1946 for the first time will again be followed of having a few sessions devoted *entirely* to the presentation of reports of technical committees. It will be noted that sessions on Wednesday afternoon, Thursday evening, and Friday morning and afternoon will be concentrated on the committee business, involving chiefly standardization matters. At these sessions the committees will ask for approval of recommendations on new and revised tentatives, tentative revisions of existing standards and for authorization to send to letter ballot of the entire Society revisions in standards or adoption of tentatives as standard, these latter actions requiring letter ballot approval of the entire Society.

Some notes about certain sessions, particularly those involving symposiums and round-table discussions, follow.

Load Tests of Bearing Capacity of Soils:

Sponsored by Committee D-18 on Soils for Engineering Purposes through a Symposium Committee headed by Prof. W. S. Housel, University of Michigan, this symposium will stimulate a critical discussion of the various load tests which have been used and will evaluate the data that have been developed over the past few years in this field. While various procedures are used and there are different opinions on analysis and application of results, interest in the test has grown, and during the war period with a huge program of airfield construction, the procedures found very wide application. The committee, through the symposium, hopes to bring order out of what some have termed chaos, through a concerted and realistic attack on the whole problem. Leading authorities are participating, covering such subjects as evaluating wheel-load capacity of pavements, designing flexible pavements, supporting capacity of soil subgrades and base courses, and methods used in Canada and on Philadelphia airfields, etc. The symposium is scheduled as the opening session of the Annual Meeting, Monday evening, June 16. On Tuesday afternoon, Committee D-18 is sponsoring another session with some papers of a more general nature. For further details, see the Provisional Program.

Measurement of Entrained Air in Concrete:

Probably no subject has aroused such interest and technical activity in the field of cement and concrete as air entrainment. The benefits of entrained air, types of materials to insure its presence in concrete, and methods of determining the amount of air have been discussed, and now through Committee C-9 on Concrete and Concrete Aggregates, this symposium will provide a comparison of various results used to determine the air content, the accuracy which might be expected, etc. The symposium committee headed by A. T. Goldbeck, National Crushed Stone Association, plans to have the principal paper followed by shorter discussions. C. A. Menzel, Portland Cement Association, who has agreed

to open the symposium, will be followed by a number of other authorities in this field who will cover such aspects as effect of sampling errors, effect of blending natural and portland cement, methods used in certain of the state highway departments, etc. Mr. Menzel in his approach plans to suggest the final standardization of a test method or methods and he will show why certain details are necessary in formulating a satisfactory procedure. This symposium is a good example of a committee bringing to bear on an important subject the enlightened views of those who have a thorough knowledge of the subject even though some viewpoints may be somewhat divergent, and then through the forum, the committee can eventually arrive at proposed standards.

Discussion on Electrodeposits:

Committee B-8 on Electrodeposited Metallic Coatings has arranged that this discussion based on three papers, will give helpful information on examination and rating of outdoor exposure test specimens. Dr. Gustaf Soderberg will discuss panels with anodic electrodeposited zinc and cadmium coatings; H. A. Pray will cover inspection of exposure test panels representingnondecorative,cathodic, electrodeposited coatings with electrodeposited lead coatings; and W. A. Wesley will describe the inspection of exposure test panels representing decorative cathodic coatings. This authoritative array of speakers will be supplemented by discussers. The entire session, scheduled for the forenoon of Wednesday, June 18, should be most interesting.

Symposium on Synthetic Lubricants:

Under the auspices of Committee D-2's Technical Committee B on Lubricating Oils headed by W. S. James, Ford Motor Co., with J. C. Geniesse, Atlantic Refining Co., Secretary, a series of speakers will cover aspects of the use of these materials in engines, hydraulic mechanisms, instruments, and accessories. Wartime developments and intensified industrial progress have compelled the lubricant specialist to meet factors unheard of a few years ago, and the symposium is to bring forth interesting discussion of problems and their solution.

Symposium on Rubber Testing:

Rubber technologists and all those concerned with the production and use of the wide diversity of products manufactured by the rubber industry will be intensely interested in this symposium being arranged by Committee D-11 on Rubber and Rubber-Like Materials. The D-11 Chairman, Simon Collier, Johns-Manville Corp., and A.S.-T.M. President Arthur W. Carpenter, Secretary of the committee, with the cooperation of other members, have arranged for an outstanding group of leading technologists to present papers in two sessions, Thursday morning and afternoon, June 19. Probably more work has been done on physical and chemical methods for evaluating rubber (with particular emphasis, of course, on American synthetic rubbers) during the past five to six years than in the preceding score of years. Much of this cleared through the Office of the Rubber Director and the Rubber Reserve Co., and the symposium committee has drawn heavily on men who were active in this program and who are now in intimate touch with it to present a great deal of data, much of which are available for the first time. President Carpenter will participate in the symposium, stressing the importance of standardization; W. R. Hucks, Deputy Director of the Rubber Reserve will participate, as well as J. W. Schade in charge of the Government Evaluation Laboratory in Akron. There is close collaboration between representatives of Government and the industry, so that an authoritative discussion will result.

Symposium on Insulating Oil:

Technical representatives of the petroleum companies, designers of apparatus and equipment, and the various utilities are vitally concerned with some of the problems in insulating oils. This 1947 symposium is the second in the series being sponsored through the work of Subcommittee IV of Committee D-9. L. B. Schofield, Commonwealth Edison Co., is heading the symposium committee, and cooperating closely is E. A. Snyder, Subcommittee IV chairman, Socony-Vacuum Oil Co., Inc. As noted in the Provisional Program, an important objective of this session is to analyze the merits of inhibitors in insulating oil to improve

From the Beach toward Chalfont-Haddon Hall.

performance, principally in transformers and cables. Just how far inhibitors can go in extending useful life is a subject for discussion. The other problem to be covered is the significance of the power factor test in connection with serviceability in transformers and cables. This session is scheduled for Tuesday afternoon, June 17.

Round Table Discussion on Identification of Water-Formed Deposits:

Continuing its series of interesting discussions and round-table conferences, Committee D-19 on Water for Industrial Uses headed by Max Hecht, Adviser, Power Stations Chemistry, has planned a session for Thursday evening, June 19 based on three pertinent papers. C. E. Imhoff, Allis Chalmers Mfg. Co., will present a basic opening paper stressing the importance of the subject, some of the various developments, etc.; Messrs. Gabriel and Jaffe, U. S. Bureau of Mines, College Park Division, will describe spectrographic analysis of deposits; and the third formal presentation by Michael Fleischer, U. S. Geological Survey, will cover problems in nomenclature in the field of mineralogy and inorganic chemistry. Many of those in this field will participate in the round table through the presentation of written or oral discussion.

1947 Edgar Marburg Lecturer Will Be Professor W. C. Voss

Well-Known Building Engineering Educator to Discuss Engineering Laminates

BOTH the subject and the lecturer for the 1947 Edgar Marburg Lecture to be delivered at the Annual Meeting of the Society at Atlantic City, should be of utmost interest to a large cross-section of the Society members. Professor Walter C. Voss, Head of the Department of Building Engineering and Construction, Massachusetts Institute of Technology, is very ably fitted through his background of structural and building engineering experience, as indicated in the biographical material which follows, to lecture on this subject.

As outlined in the synopsis appearing below, engineering laminates represent the latest development in complex structural materials, that were stimulated by the necessities of war, while at the same time present the latest problems in complicated fundamental research. Embracing a broad field of metals, nonmetals, and bonding agents, the lecture should be of particular interest to the many technical committee members interested in the many types of materials so involved.

The Marburg Lecture, first established in 1925, has each year until 1945 when the event was postponed because of wartime restriction on meetings, brought to the Annual Meeting leaders in their respective fields. These men described in lectures which when subsequently published have been heralded as major contributions to technical literature, outstanding developments in our knowledge of engineering materials. The lecture commemorates the name of the Society's first Secretary who, through his development of technical programs and in other ways, brought wide recognition to A.S.T.M. as a forum for the discussion of tests and properties of materials.

Walter C. Voss

The 1947 lecture, to be held in the Vernon Room of Haddon Hall, June 18, will start at 4.30 p.m.

Synopsis of 1947 Marburg Lecture on Engineering Laminates

THE problems underlying the inhomogeneity of the materials used in the production of engineering laminates have their basis in the fundamental sciences and still pose a vexing problem to the profession. Laminates have been used extensively during the war for a wide variety of structures, among which the airplane and the boat are outstanding examples.

Engineering laminates, as conceived by most investigators, should be broadly construed as including metals, wood, plastics, and fabric combined each to each and each to the other. We thus find that the problem of adhesion plays a very important rôle.

To understand thoroughly the forces which are acting when adhesion takes place, it is necessary to relate the problem to the various types of chemical bonds. This involves the effects of the surface characteristics of the various materials in the presence of atmospheric conditions and also in the presence of surface characteristics of another material under similar conditions.

The tremendous progress made by the plastics industry during the war has indicated a very definite trend in the study and testing of materials. As most of the plastics are based upon some of the simpler structures of our materials, it was possible to produce synthetic materials by the processes of analysis and synthesis. Somewhat the same approach will probably have to be made to the more complex structures such as metals and silicates. To unravel the complicated fundamentals of these materials will be a long and arduous task. Nevertheless, the tendency in the technique of approach will most certainly swing in the same direction as was used in the plastics industry.

Laminates will undoubtedly become one of our more important sheet and structural materials and by the proper selection of the individual sheets forming the laminate will greatly affect the cost of many products

and their durability. With the possibility of selecting a variety of materials which are known to satisfy certain conditions necessary to their use and then combining them in a laminate to accomplish a compound objective, we will probably be able to provide more satisfactory products.

The studies which have been made of laminates and of the materials used in their construction have indicated that a vast amount of fundamental research is still necessary before we will be able to predict the behavior of a laminate with any degree of confidence.

About the Lecturer, Professor Voss

WALTER C. VOSS first saw the light of day in Chicago, Ill., where he received his elementary schooling. He was graduated from Chicago Teachers College in 1907, and later attended the University of Illinois, receiving his B.S. in 1912 from that institution. Massachusetts Institute of Technology awarded him his M.S. in 1932.

From 1907 to 1910 he was instructor in manual arts in Chicago. Later (from 1912 to 1914) he was associated in detailing and designing reinforced concrete and structural steel with engineering and architectural firms in Chicago; and subsequently was engaged as private consultant in architectural construction and materials. In 1914 he received appointment as head of the Department of Architectural Construction of Wentworth Institute, Boston, in which capacity he served until 1925. From 1925 to 1928 he was employed as district structural engineer of the Portland Cement Association, Boston. Since that time he has been affiliated with the faculty of the Massachusetts Institute of Technology as Professor of Building Engineering and Construction; in 1940 he was named Head of his department, and at present he also serves as Director of the Building Materials Research Laboratory of M.I.T.

From 1941 to 1945, he was a member of the technical advisory committee of the Massachusetts Commission on Public Safety, and during the same period served as Consultant to First Defense Region Office of Civilian Defense.

He is a Director of the California Stucco Products Co.; a member of the National Panel Arbitrators, National Arbitration Association; and Chairman of the Executive Committee, City Com. Uniform Safety Law, Massachusetts.

He has also been very active in the work of technical and professional organizations including the American Association for the Advancement of Science, American Society of Civil Engineers, Boston Society of Civil Engineers, American Institute of Architects, American Concrete Institute, American Ceramic Society, Society for Promotion of Engineering Education, International Association of Bridge and Structural Engineers, Society for Experimental Stress Analysis, American Academy of Social Sciences, American Society for Testing Materials, and others. He has been particularly active in the work of A.S.T.M. Committee C-7 on Lime and its subcommittees, and is the present chairman of Committee C-7. In addition he serves on Committees C-12 on Mortars for Unit Masonry, and E-6 on Methods of Testing Building Constructions. He also is a member of the Administrative Committee on Research of A.S.T.M., and of the New England District Council.

Professor Voss has written several volumes on concrete work and architectural construction and related subjects.

In 1915 he married Loretta M. Kensella. His home is on Old Town Road, Wellesley Farms, Mass.

Notes on Publications

Proceedings Largest Yet; Other Items Cover pH Measurement, Standards for Spectrochemical Analysis, Contact Materials, Special Compilations of Standards

MOST NOTEWORTHY of the several A.S.T.M. publications recently completed or scheduled for completion in the very near future, are the 1946 *Proceedings*. This volume, containing technical papers and reports presented at the annual and other meetings, is the largest in point of size of any *Proceedings* yet issued, aggregating 1614 pages—a great wealth of material.

Another publication of much interest and value to those who are concerned with this subject is the Symposium on pH Measurement, and there is a completely revised report on Standards for Spectrochemical Analysis. The 1946 Supplement to the Bibliography and Abstracts on Electrical Contacts is also nearing completion.

Compilations of standards which are being issued include a reprinting of the one on soils which has been out of print for some months, the 1947 compilation on coal and coke; and similar publications covering the field of plastics and rubber products will probably be available about the time of the annual meeting or perhaps shortly thereafter.

1946 Proceedings:

While much of the material in the 1946 *Proceedings* was preprinted and distributed in advance of the Annual Meeting, quite a number of technical papers and reports are published for the first time in this volume. Papers which were not preprinted and hence will be seen by the members for the first time include the following:

Atmospheric Corrosion Tests on Corrosion-Resistant Steel—G. L. Snair, Jr.

Fatigue Tests on Some Additional Copper Alloys—Alton R. Anderson, Emery F. Swan, and Earl W. Palmer

The Notch Sensitivity in Fatigue Loading of Some Magnesium-Base and Aluminum-Base Alloys—George H. Found

Fatigue of Wood and Glued Wood Constructions—Wayne C. Lewis

Investigation of Materials for Marine Propellers—W. C. Stewart and W. Lee Williams

Pneumatic Fatigue Machines—F. B. Quinlan

Resistance of Iron-Nickel-Chromium Alloys to Corrosion in Air at 1600 to 2200 F.—Anton deS. Brasunas, James T. Gow, and Oscar E. Harder

Compressive Stress-Strain Properties of Some Aircraft Materials—P. E. Sandorff and R. K. Dillon

A Permeameter for Metals Used in Cathode-Ray and Television Tubes—Howward J. Evans

The Calculation of Electrical Contacts Under Ideal Conditions—Erle I. Shobert II (published in the 1946 Committee B-4 compilation)

A Study of the Tension Test—Earl R. Parker, Harmer E. Davis, and Alan E. Flanigan

Modulus of Elasticity of Aggregates and Its Effect on Concrete—H. A. LaRue

The Use of the Dynamic Modulus of Elasticity in Predicting the 28-Day Flexural Strength of Concrete—E. F. Preece

A Study of Durability and Void Characteristics of Concretes Containing Admixtures, Principally of the Air-Entraining Type—F. B. Hornibrook, Howard

Freidburger, and Albert Litvin

Permeability of Brick-Mortar Assemblages—J. W. McBurney, M. Arnold Copeland, and Russell H. Brink

Method of Test for Evaluating Soil Bituminous Mixtures—E. O. Rhodes and P. F. Phelan

A Method of Obtaining the Particle Size of Colloids from Sedimentation of Data Obtained with the Sharples Supercentrifuge—Serge A. Loukomsky and James O'Brien

Effect of Weathering on Insulation Resistance of Plastics—Leslie H. Campbell, Arthur H. Falk, and Robert Burns

Electrical Quality Classification of Raw-Mica by a Rapid, Direct-Reading Test Method—K. G. Coutlee

Grease Analysis—An Analysis of the A.S.T.M. Method and Suggestions for Improvement—Robert S. Barnett, Walter Scott Palmer, and Harry Levin

It is expected the distribution of this extensive volume, which is furnished to the members as one of the publications they receive by virtue of their affiliation with the Society, may start about May 26, and the printer hopes to start mailing copies a few days later to the large number of orders which are received from various libraries and other sources both in this country and abroad. The list price of this publication is $12, members can obtain extra copies at $8.

Report on Standard Samples for Spectrochemical Analysis:

This publication, which is an extensively revised and amplified edition of the report prepared by Messrs. Brode and Scribner in September, 1943, gives the latest information on available materials and standards for spectrochemical analysis. The report covers definitions and nomenclature and lists available, standard samples on iron and steel, aluminum and its alloys, magnesium and its alloys, zinc, lead, and tin alloys, copper alloys and miscellaneous materials. Under the chairmanship of C. H. Corliss, National Bureau of Standards, Subcommittee IV on Standards and Pure Materials functioning under A.S.T.M. Committee E-2 on Spectrochemical Analysis has made an extensive canvass, and the data and discussion recorded here should be of widespread interest and service. The compiling of information of this kind and its subsequent publication is one of those services which can be handled in an efficient manner through an A.S.T.M. technical committee, and Mr. Corliss and his subcommittee are to be complimented on the work underlying this new report. The book can be procured by members of the Society at 90 cents per copy, the list price being $1.25.

The *1946 Supplement to the Bibliography and Abstracts on Electrical Contacts* is a reflection of an activity in Committee B-4, and particularly the work of Erle I. Shobert, II who directs this phase of the work for Committee B-4. This is the third supplement to the original bibliography which was issued early in 1944 covering the years up through 1942. A supplement issued in May 1945, brings the data up to date through 1944; the second supplement, issued in May, 1946, covers the calendar year 1945; and the supplement now on press will bring the data up to date through December 31, 1946. This new supplement will be furnished to members at 60 cents per copy, the list price being 75 cents. A set of the publications including the original book with three supplements can be obtained by members at $5.00, the list price being $6.50.

Symposium on pH Measurement:

The principal purpose of this symposium which includes seven extensive technical papers and discussion, was to present the latest theory and practices on the various methods such as colorimetric and potentiometric methods for making pH and closely related measurements. The authors are experts in the field of pH determinations, and their contributions should be very pertinent to those who are interested in such work. The symposium consists of the following seven papers:

Recent Advances in the Theory and Use of Glass Electrodes for pH Determinations—Malcolm Dole

Definition of pH and Extension of the Acidity Scale to Nonaqueous Systems—D. S. McKinney, Paul Fugassi, and J. C. Warner

Acid-Base Equilibria in Aqueous and Nonaqueous Solutions—Martin Kilpatrick

The Potentiometric Estimation of Hydrogen Ion Concentration in Nonaqueous Media—L. Lykken

Standard Buffer Solutions—George G. Manov

Precautions to Be Observed in Making Colorimetric pH Determinations—F. R. McCrumb

Historical Review of the Hydrogen Electrode and the Calomel Cell in the Measurement of Hydrogen Ions—C. N. Meyers

The book aggregates about 100 pages. List price, $1.50; to A.S.T.M. members, $1.15. This is not a reprint from the *Proceedings*, but is available only in this volume.

Index to A.S.T.M. Standards

THE Combined Index to the 1946 Book of A.S.T.M. Standards should be available sometime in early June. Work on this publication cannot be expedited until the last part of the Book of Standards has been virtually completed and with the delay in completing Part IIIB of the 1946 Book this means that the 260-page 1946 Index to Standards cannot be completed before about June 5.

This Index is a decided convenience since it will be a detailed index to *all* five Parts of the big Book of Standards. The main portion of the Index lists the specifications under appropriate key words but use is made of convenient cross references so that the material will be as concise as possible. Under each key heading an effort is made to select the most significant word in the title of the specifications so that there is some alphabetical sequence.

A most valuable part of the Index is the list of standards in numeric order of their serial designations, and in these lists, too, reference is made to the official source of latest publications.

Distribution of the Index.—A copy of the Index will be sent to each A.S.T.M. member and committee member, and in addition a copy is furnished to all members or nonmembers who *purchase* any parts of the book.

The Index is distributed on request and several thousand purchasing agents and others who are concerned with A.S.T.M. standards get the publication regularly. Some organizations get several copies of the publication to distribute to their key technical people.

We recommend that this Index be placed convenient to the Book of A.S.T.M. Standards. Its use will save much time in locating any particular items the locations of which are not known.

A.S.T.M. Technical Series Developed

SINCE the publication of "The Life and Life Work of Charles B. Dudley" in 1911, the first special publication of the Society, a memorial volume to the first president of A.S.T.M. (1900–1909), the Society has issued many technical books, pamphlets, and charts which have not been included in the *Proceedings*, *ASTM Bulletin*, or *Book of Standards*. In view of the value of these publications to research workers, engineers, industrialists, and students in specialized fields, on the recommendation of the Administrative Committee on Papers and Publications, these publications have been collected chronologically into an A.S.T.M. Technical Series and given a Technical Publication Number. As other special publications become available they will be numbered in the sequence in which they appear. This number will be printed on them and can be used in ordering copies.

The Technical Series, a list of which follows, includes all the separate publications issued by A.S.T.M. either as one or jointly with other societies. The Series does not include special publications that are reprints from the *Book of Standards* or *Proceedings*, such as compilations of standards and the several symposiums published in *Proceedings*. The publications in the Technical Series are made available to members at special member prices.

If any members have copies of publications indicated as being out of stock, particularly those for which we do not have a copy for our official library file, and would be willing to sell them back to the Society we should indeed be pleased to be so advised.

Technical Publication Number	Title
†1	The Life and Life Work of Charles B. Dudley (Memorial Volume) (1911).
†2	Selected Standard Specifications for Steel and Steel Products (In English, German, French, and Spanish) (1912).
†3	Reports of the Committee on Preservative Coatings for Structural Materials (1914).
†4	Data Considered by Committee C-1 in Preparing the Standard Specifications and Tests for Portland Cement (First and Second Reports of the Joint Conference on Uniform Methods of Tests and Standard Specifications for Cement) (1919).
†5	Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete (1924).
5-A	Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete, Recommended Practice and Standard Specifications for Concrete and Reinforced Concrete (Published with and without Supplement) (1940).
*6	Annotated Bibliography on Impact Testing (Special Mimeograph pamphlet).
7	The Significance of Tests of Petroleum Products (Reprinted from 1928 Proceedings but included here because it represents the first of a series).
7-A	The Significance of Tests of Petroleum Products (1934).
†8	Glossary of Definitions of Terms Appearing in A.S.T.M. Standards and Tentative Standards (Special mimeograph pamphlet) (1929).
†9	Abstracts of Articles on Fatigue of Metals Under Repeated Stress Appearing in the Technical Press from July 1, 1928 to June 30, 1929 (1929).
†9-A	Abstracts of Articles on Fatigue of Metals Under Repeated Stress Appearing in the Technical Press from July 1, 1929 to June 30, 1930 (1931).
†10	Symposium on Developments in Automotive Materials (Detroit Regional Meeting, March 19, 1930).
†11	Symposium on Welding (Pittsburgh Regional Meeting, March 18, 1931).
12	Symposium on Effect of Temperature on Metals (1931).
†13	Symposium on Rubber (Cleveland Regional Meeting, March 2, 1932).
*14	Joint Committee on Test Methods and Forms (1933).
15	A.S.T.M. Manual on Presentation of Data (With Tables of Squares and Square Roots) (1933).
15-A	Second printing—Including Supplements A and B (1937).
15-B	Third printing (1940).
16	Symposium on Motor Lubricants (New York Regional Meeting, March 8, 1933).
†17	Symposium on the Outdoor Weathering of Metals and Metallic Coatings (Washington Regional Meeting, March 7, 1934).
†18	Symposium on Paint and Paint Materials (Philadelphia Regional Meeting, March 6, 1935).
†19	Discussion on the Significance of "Yield Strength" of Metals in Design and Specifications (Mimeographed) (1935).
20	Symposium on the Place of Materials in Automobile Roads and Rides (1935).
†21	The Role of Materials in Modern Housing (1935).
22	Report on Significance of Tests of Concrete and Concrete Aggregates (1935).
†22-A	Report on Significance of Tests of Concrete and Concrete Aggregates (Second Edition) (1943).
†23	Symposium on Industrial Fuels (1936).
24	Symposium on High-Strength Constructional Metals (Pittsburgh Regional Meeting, March 4, 1936).
†25	Symposium on Pearlitic Malleable Cast Iron (1936).
†26	Data on Nominal Creep Strength of Steels at Elevated Temperatures (1936).
27	Proposed Methods of Analysis of Industrial Waters (1936).
†28	Symposium on Radiography and X-ray Diffraction (1936).
†28-A	Symposium on Radiography (1943).
29	Symposium on Lubricants (Chicago Regional Meeting, March 3, 1937).
†30	Symposium on Wear of Metals (1937).
31	Viscosity-Temperature Charts (1937).
†32	Symposium on Corrosion Testing Procedures (1937).
33	Symposium on Correlation Between Accelerated Laboratory Tests and Service Tests on Protective and Decorative Coatings (1937).
†34	Symposium on Consistency (1937).
†35	Symposium on Plastics (Rochester Regional Meeting, March 9, 1938).
†36	Symposium on Protecting Metals Against Corrosion (1938).
†37	Compilation of Available High-Temperature Creep Characteristics of Metals and Alloys (1938).
†38	Standard Specifications for Gypsum Plastering (Published Jointly with the American Institute of Architects) (1938).
39	Symposium on Thermal Insulating Materials (Columbus

† Out of stock.
* Not available in our official library set.

Regional Meeting, March 8, 1939).
40 Symposium on Lime (Columbus Regional Meeting, March 8. 1939).
41 Index to the Literature on Spectrochemical Analysis 1920–1937 (1939).
41-A Index to the Literature on Spectrochemical Analysis 1920–1939 (1941).
42 Viscosity Index Tables (1940).
43 Conversion Tables for Kinematic and Saybolt Universal Viscosities (1940).
44 Symposium on New Materials in Transportation (Detroit Spring Meeting, March 6, 1940).
45 Evaluation of Petroleum Products (1940).
†46 Topical Discussion on Radiographic Testing of Airplane Components (1941).
†47 Impact Resistance and Tensile Properties of Metals at Subatmospheric Temperatures. Prepared by H. W. Gillett (1941).
48 X-ray Diffraction Data Cards for Chemical Analysis (1941) Index, 1941. Second Index, 1945.
48-A Supplementary X-ray Diffraction Cards (1944). Index, 1945.
49 Cotton Yarn Appearance Standards (1941).
50 Symposium on Color (Washington Spring Meeting, March 5, 1941).
51 Symposium on New Methods for Particle Size Determination in the Subsieve Range (Washington Spring Meeting, March 4, 1941).
52 Tables of Data on Chemical Composition, Physical and Mechanical Properties of Wrought Corrosion-Resisting and Heat-Resisting Chromium and Chromium-Nickel Steels (1942).
53 Hardenability of Steel (Chart) (1943).
53-A Hardenability of Steel (Chart) (1946).
54 Symposium on Paint (Buffalo Spring Meeting, March 3, 1943).
55 Symposium on Powder Metallurgy (Buffalo Spring Meeting, March 3, 1943).
56 Bibliography and Abstracts on Electrical Contacts (1943).
56-A 1944 Supplement to the Bibliography and Abstracts on Electrical Contacts (1945).
56-B 1945 Supplement to the Bibliography and Abstracts on Electrical Contacts (1946).
57 Symposium on Mildew Resistance (1943).
58 Report on Standard Samples for Spectrographic Analysis by W. R. Brode and B. F. Scribner (1944).
59 Symposium on Plastics (1944).
60 Paper and Paperboard, Characteristics, Nomenclature, and Significance of Tests (1944).
61 Symposium on the Applications of Synthetic Rubbers (1944).
62 Symposium on Magnetic Particle Testing (1945).
63 Report on Behavior of Ferritic Steels at Low Temperatures by H. W. Gillett and Francis T. McGuire (Part I text, Part II Illustrations) (1945).
64 Symposium on Stress-Corrosion Cracking of Metals (Published Jointly with the American Institute of Mining and Metallurgical Engineers) (1945).
65 Symposium on Adhesives (1946).
66 Discussion on Statistical Quality Control in Its Application to Specification Requirements (Pittsburgh Spring Meeting, February 26, 1946).
67 Symposium on Atmospheric Exposure Tests on Non-Ferrous Metals (Pittsburgh Spring Meeting, February 26, 1946).
68 Symposium on Materials for Gas Turbines (1946).
69 Symposium on Oil Procurement Practices (1946).
70 Symposium on Bearings (1947).
71 Forum on Diesel Fuel Oils (1947).

Actions on Standards

Tests of Panels for Building Construction and Terms on Adhesives Approved

Two important recent actions by the Committee on Standards include the approval of new methods of conducting strength tests of panels for building construction (E 72) and a series of definitions of terms relating to adhesives (D 907).

Testing Building Panels:

The procedure for conducting strength tests of panels was recommended by Committee E-6 on Methods of Testing Building Constructions, organized in 1946. This group has for its scope the formulation of methods of test for building constructions, including elements, connections and assemblies, under actual or simulated service conditions, applicable to the evaluation of such factors as materials, design, construction, and fabrication.

H. L. Whittemore was chairman of the subcommittee responsible for the new test, the first A.S.T.M. has issued in this field, and it is no coincidence that he with A. H. Stang prepared the report and carried out the work covered in the National Bureau of Standards Report BMS2 discussing the determination of structural properties of low-cost house constructions. It is the method covered in this report which formed the basis of the new test E 72. The method follows quite closely the significant data in the BMS report. Procedures covered are evaluating the structural properties of wall specimens under compressive, transverse, concentrated, impact, and racking loads; of partition specimens under impact and concentrated loads; of floor specimens under transverse, concentrated, and impact loads; and of roof specimens under transverse and concentrated loads. A graphic method of presenting the results of the tests is also described.

Adhesive Terms:

The importance of agreeing on definitions of terms is evident by the fact that many of the newer technical committees particularly, contrate their early work on definitions of terms. Committee D-14 on Adhesives, through a subcommittee headed by G. M. Kline, has been reviewing quite a number of terms used in the adhesives field and there has been excellent agreement in the subcommittee and main committee on the numerous definitions. Such terms as adhesive, cure, inhibitor, mechanical adhesion, etc., are covered. Adhesion is indicated as the state in which two surfaces are held together by interfacial forces which may consist of valence forces or interlocking action or both. There is a reference to mechanical adhesion and specific adhesion.

Copies of these two new tentatives E 72 and D 907 should be available in the next few weeks and a copy will be furnished to any A.S.T.M. member on request. It is expected that each of the tentatives will be appended to the preprints of the 1947 reports of the respective committees.

Significance of Numerical Limits in Specifications

Editor's Note.—This article was prepared by H. F. Dodge as Chairman of Committee E-11 on Quality Control of Materials as a result of a request which indicated that wider application of the Tentative Recommended Practices for Designation of Numerical Requirements (E 29 – 40 T) might be found advantageous in the preparation of A.S.T.M. specifications.

SUPPOSE a specification for a certain type of non-ferrous rods includes the following requirement, among others, for chemical composition: Iron, maximum, 0.10 per cent. Then suppose a lot of these rods has been offered for acceptance, suitable samples of thoroughly mixed drillings have been prepared for chemical analysis, and the analyst finds that the sample contains 0.102 per cent iron, as indicated in Fig. 1. Does this indicate conformance to the specified requirement of maximum 0.10 per cent or not? Should the lot of rods be accepted or rejected?

Here is a situation that often leads to misunderstanding and disagreement if the specification has made no statement regarding the significance of the numerical limit of maximum 0.10 per cent, that has been specified. Such a limit has been subject to two different interpretations. One group holds that an observed or calculated value obtained from analysis should first be rounded off to the number of decimal places indicated in the prescribed limit and that the rounded value should then be used for determining whether the lot should be accepted or rejected. This group would say "Accept" the lot illustrated in Fig. 1. A second group says that a specified maximum value such as 0.10 per cent is absolute, that any value that exceeds 0.10, no matter how small the excess and regardless of how far the calculations may have been carried out (for example, 0.10001), fails to conform to the specified limit. This group would say "Reject" the lot illustrated in Fig. 1.

Which is right? In the absence of specific instructions in the specification, there appears to be no definite answer.

This problem and the method of handling it is covered in Recommended Practices for Designation of Numerical Requirements in Standards (E 29 – 40 T).[1] There it is indicated that the unqualified statement of a numerical limit, such as "0.10 per cent, maximum," "2.500 in., maximum," "62,000 psi., minimum," cannot, in view of different established practices and customs in different fields, be regarded as carrying a definite operational meaning with respect to the number of places of figures to be retained in an observed or calculated value for purposes of acceptance and rejection. E 29 goes on to say that in some fields a specified value such as 0.10 maximum is taken to imply that for purposes of acceptance and rejection observed values or calculated values should be rounded off to the nearest 0.01 per cent; in other fields, a specified value such as 0.10 maximum is taken to imply an absolute value, that is, no deviation from this value is allowed, no matter how small the deviation. E 29 states further that clear meaning on this point can be assured only by specifying "how the observed values or calculated values are to be handled when they are compared to specified values in determining acceptability of materials." But E 29 leaves the specification committee entirely free to choose which of these two methods it wishes to impose.

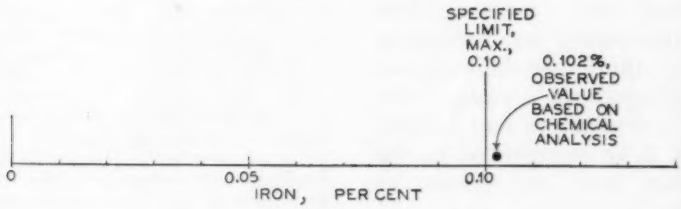


Fig. 1.

A number of the B committees have elected the first of these two alternatives, namely, the rounding-off procedure when referring to specified limits for chemical composition. Note, however, that the specification committees were entirely free to use the second of these two alternatives if they so chose. The decision to use the first of these two alternatives, namely, the rounding-off procedure, is indicated precisely in the specification by adding a note at the bottom of the table giving chemical requirements. For example, in the Tentative Specifications for Beryllium-Copper Alloy Wire (B 197 – 46a T),[2] the following note appears in Section 4 under the table of requirements on chemical composition:

"For purposes of acceptance or rejection, an observed value or calculated value obtained from analysis should be rounded off to the nearest unit in the last right-hand place of figures used in expressing the specified limit, in accordance with the rounding-off procedure prescribed in Section 4 of the Tentative Recommended Practices for Designation of Numerical Requirements in Standards (A.S.T.M. Designation: E 29)."

It is noted that E 29 covers not only the problem of specified limits for chemical composition but for other types of numerical requirements as well. For example, in some specifications, the rounding-off procedure has been specified for some mechanical test requirements. This has been done in the above-mentioned specifications (B 197–46a T), which includes the following note in Tables II and III covering requirements for tensile strength:

"For purposes of acceptance or rejection, an observed value or calculated value obtained from the tension test should be rounded off to the nearest 1000 psi. in accordance with the rounding-off procedure prescribed in Section 4 of the Tentative Recommended Practices for Designation of Numerical Requirements in Standards (A.S.T.M. Designation: E 29)."

Thus it is possible, by clear statement in the specification, to avoid misunderstanding and disagreements in instances where observed values are marginally close to specified values.

[1] 1946 Book of A.S.T.M. Standards, Part I-A, p. 1128; Part I-B, p. 891; Part II, p. 1686; Part III-A, p. 1235; Part III-B, p. 1310.
[2] 1946 Book of A.S.T.M. Standards, Part I-B, p. 445.

ASTM Bulletin

MAY 1947

NO. 146

NINETEEN-SIXTEEN
RACE STREET
PHILADELPHIA 3, PENNA.

Standards of Reasonableness

HENRY MARION HOWE, long-time professor of metallurgy at Columbia University, and certainly one of the most inspiring men in his field, was a leader in the formation of A.S.T.M. He was head of the organization the year of its incorporation, was one of the incorporators, and was honored by another term as A.S.T.M. president from 1910 to 1912. He wrote many significant things. Elsewhere in this BULLETIN is noted the receipt of the first edition of his book "The Metallurgy of Steel." The writings of men of Howe's stature embody thinking and suggestions which are as valuable today as when written or uttered. In his annual address in 1902, describing the difference between the American viewpoint and that of the European members, he states, "We American members look to the erection of normal or standard reception specifications as by far the more important object." He goes on to stress the importance of reasonableness: "It appears to us that buyer and seller have greater difficulty in agreeing on the specifications which the material bought and sold must fulfill, than in agreeing on the methods to be used for deciding whether those specifications, once agreed on, are fulfilled by a given lot of material. We do not expect, nor do we think it important, that the standard specifications which we erect shall be exactly complied with in many, or indeed in any, actual transactions. But we are firmly convinced that the existence of such standard specifications, stamped as *standards of reasonableness* by a properly constituted body such as we aim to be, will greatly facilitate agreement between buyer and seller, will help them to come to terms, to convince each other that this or that item specified by one of them and objected to by the other is or is not reasonable. *Reasonableness* should be the spirit in which every negotiation is carried on; standards of reasonableness such as we wish to erect should greatly aid reasonable men in deciding what is reasonable. While we believe this true of domestic negotiations, we believe that it applies with even greater force to international negotiations, between buyer and seller who have never seen each other, who live under different conditions of society, with different traditions, concepts, and points of view.

"No words are needed to show the great importance of this field of work. It is well that there should be some society with this as its chief object. Such a society should have very strong international affiliations; these we have. It should represent both sides of the negotiations, seller and buyer, maker and user. It should represent also what we may term their professional counsel, the consulting and inspecting engineers. If I may still further borrow the terms of litigation, it should represent also the bench, that is to say the institutions of learning, through their teaching and investigating staff, and the engineering press. These three classes, I repeat, first, the negotiators themselves, maker and user; second, their counsel, the testing and consulting engineers; third, the disinterested and quasi-judicial class, the teachers, investigators and editors, should be fully represented in our membership and our Executive Committee."

It is our conviction that one of the important stones—if not in fact the keystone in the arch of progress and recognition—is the one labeled "reasonableness." Today, as in the time of Howe and his associates such as Dudley and Marburg, one of the motivating forces in our technical activities is that of compromise, a spirit of "give and take." We repeat again the statement from John Capp, outstanding leader in A.S.T.M. work and in the electrical industry: "Usually a man comes from an A.S.T.M. technical committee meeting, not with what he thinks he ought to have, but with what he ought to have."

Proposed Changes in By-Laws

MINOR changes are desirable in the section of the By-laws dealing with the nomination of officers, to take cognizance of the fact that the meetings of the Board of Directors now are held three times yearly instead of quarterly. The former October meeting is now scheduled in September and recommendations from the members for appointments on the Nominating Committee must be canvassed earlier. Following approval at the Annual Meeting the following changes will be referred to letter ballot:

The dates in italics, namely, July 1 and August 15, will be substituted, respectively, for the dates September 1 and October 1.

Article III. Nomination of officers

Sec. 2. Not later than [September 1] *July 1* of each year the Executive Secretary shall notify every member of the Society that he has the right to recommend two members for appointment on the nominating committee. The procedure governing the transmission of such recommendations shall be designed to ensure secrecy as to individual authorship. A committee of tellers appointed by the President shall canvass the recommendations which have been received by the Executive Secretary prior to [October 1] *August 15*, and shall transmit the returns to the Executive Secretary in time for presentation to the Board of Directors at its first regular meeting thereafter.....

Vice-President Boyd and B. P. Resseger Discuss Gasoline and Automotive Rubber at Rochester Meeting

Two very interesting papers featured the joint meeting in Rochester on Thursday, March 13, sponsored by the A.S.T.M. Western New York-Ontario District, the Rochester Section of The American Society of Mechanical Engineers, and the Rochester Engineering Society. A.S.T.M. Vice-President T. A. Boyd, Head, Fuel Department, Research Laboratories Div., General Motors Corp., Detroit, Mich., discussed in a most interesting manner the topic "Gasoline—Yesterday, Today, Tomorrow," and B. P. Resseger, Field Engineer, Industrial Products Div., The B. F. Goodrich Co., Akron, Ohio, covered "Rubber in Automotive Engineering."

The program had been arranged for the district council by Louis Shnidman, Laboratory Director, Rochester Gas and Electric Corp. At the meeting, he introduced the heads of the Rochester Engineering Society, The American Society of Mechanical Engineers, Rochester Section, and A.S.T.M. District Chairman, T. L. Mayer, Department of Technology, Buffalo Public Library. Following an outline of the establishment of the Society, its purposes and objectives, and a case history of how its technical committees work (this covering Committee D-20 on Plastics which had arranged the technical feature of the last meeting held in Rochester in 1938, namely, a symposium on plastics) and some pertinent comments by C. H. Fellows, Chairman of the Administrative Committee on District Activities, two papers were presented.

Gasoline—Yesterday, Today, Tomorrow:

An outstanding authority on the subject of automotive fuels, Mr. Boyd covered the subject in a way that was of interest to the mixed engineering group present. He pointed out that gasoline is the second most plentiful liquid in the world, although about 45 years ago it was just a drug on the market, but for some decades the petroleum refiner has been kept stepping to provide sufficient fuel of the quality desired. He described the ideal gasoline in relation to five properties: (1) plentiful, (2) low in cost, (3) easy to vaporize (4) high in energy content, and (5) free from knock. He mentioned that A.S.T.M. had detailed tests covering particularly the last three items. To stress the consumption of gasoline which is now 30 billion gallons a year, he used the following example: If the gasoline now being used each year were in tank cars running past as you stood beside a railroad track, a 10,000-gal. tank car would have to click past every 10 seconds day and night continuously throughout the whole year to carry the gasoline now being consumed. He pointed out through a series of slides that two thirds of the world's production of oil has been coming from our wells. The question of how long the oil will hold out was considered in light of various ill-founded predictions, and Mr. Boyd said that proven reserves of petroleum have kept far ahead of production and consumption for over 80 years. He cited improvements in the technology of discovery, namely, the use of better instruments, new drilling methods, electrical logging of wells, as well as a method of gas recycling and water flooding which makes it possible to get two or three times as much oil out of a field than formerly was the case. He also referred to a newer scheme now under trial which uses a bacteriological method to get the maximum out of the oil sands. In referring to the possibility of petroleum shortage, he showed the various sources from which we can get

Knock-Testing Engines at Ethyl Testing Laboratory, Yonkers, N. Y.

Photo courtesy *Ethyl News*.

gasoline instead of from oil. They include natural gas, oil shales, and coal which have potential petroleum reserves many times that of the natural oil. In commenting on the Fischer-Tropsch process, he referred to the tremendous expenditure of a leading Middle West company in its new plant in western Kansas for making gasoline from natural gas to compete with the other more widely used processes.

Commenting on cost, he showed the great reduction that had been made from the standpoint of the refiner, and mentioned the greatly increased taxes on gasoline. Not only is the price today about half of what it was in 1920, but the car user gets many more miles per gallon.

In connection with volatility, he concluded that while gasoline has been improved in this respect, the desirability of high octane numbers and the use of the catalytic cracked stocks may reverse the trend. In other words, the octane will step up; the ease of vaporization will drop. In connection with energy, he showed that a pound of gasoline has three times as much energy as a pound of T.N.T., and seven times as much as a pound of dynamite. Freedom, from knock is desirable, not only from the standpoint of sound, but also because knocking quality limits the compression ratio of the engine. He explained clearly the use of reference fuels in determining the knock characteristics by the A.S.T.M. methods, and to emphasize the advantages of a high compression engine, he described one with a ratio of nearly 13 to 1 which gives greatly improved mileage over current cars and has thoroughly satisfactory operation.

B. P. Resseger

In concluding, he referred to the important work of A.S.T.M. Committee D-2 in setting up test methods for gasoline and other petroleum products. He said, "Fortunately, gasoline is a material which is not too difficult to test and to specify. It is also a wonderful liquid and one which we are extremely fortunate in having in such plentiful amounts."

Rubber in Automotive Engineering:

Launching his discussion with a brief historical review, Mr. Resseger cited our country's consumption of rubber in the year ending March 31, 1941 (just prior to the war) as 684,000 tons, in comparison with 4000 tons in 1870, when Dr. Benjamin Franklin Goodrich established in Akron, Ohio, the first rubber company west of the Allegheny Mountains. The sole source of supply at that time, the wilds of South America and West Africa, continued to furnish practically all natural rubber used throughout the world until 1910, when the Far Eastern plantations started from seeds taken from Brazil to England and then transplanted in Ceylon, commenced to compete with wild rubber; and by 1915, the production of plantation rubber had equalled that of wild rubber. Under stimulus of the rapidly expanding automotive industry, plantation rubber acreage continued to be increased until in the pre-war year of 1940 the total world production was approximately 1,400,000 tons, of which United States consumed 46 per cent, rubber then being our largest single import. He compared the price of 22¢ per pound in 1940 with the average of $2 per pound back in 1910.

He stressed the significance to the rubber technologist of the loss of over 90 per cent of our crude rubber producing territory following the bombing of Pearl Harbor and the overrunning by the Japanese of the Malay Peninsula and the Dutch East Indies. Faced with the appalling situation of equipping the most prodigious array of mobile fighting equipment the world had ever seen, the rubber industry, after 100 years' experience with natural rubber, had to reorient itself in literally 100 days to working with the synthetic rubber-like material available. The industry fortunately was prepared to meet the emergency, since as early as 1925 there was intensive work on the development of synthetic rubber-like materials, in 1937 there was commercial production of butadiene type synthetic rubbers, and in June, 1940, his own company introduced for sale an automobile tire in which American-made rubber replaced natural rubber by more than half.

With national attention focused on the critical rubber supply problem, the construction of government-owned plants for American rubber production was accelerated and by the end of 1944, the industry was operating at the rate of more than 1,000,000 tons per year.

As to future prospects, Mr. Resseger felt that before the end of this year the rubber industry should have a sufficiency of both American-made rubbers and natural rubber with which to work, thus affording a broader scope of opportunities for our technologists. He reported much progress already in improvement of quality of American-made rubber and in performance of end products. He felt that many more than the present six man-made commercially used rubbers would be developed, to meet specific problems and he envisaged many changes as research paved the way to a better and better product, or as differentials developed in relative costs of materials available.

Commenting on the primary purpose of its use in an automobile for isolating or minimizing vibration, he termed rubber "the strong man of the circus" when compared with other common engineering materials, its resilient energy in foot pounds per pound of material being most outstanding; for example: spring steel rates 95, hickory wood 122, and vulcanized rubber 14,600.

Briefly noting a total of approximately 265 engineered rubber parts exclusive of tires and tubes in the DeLuxe class car, he concentrated on the use of American-made rubber in what most people think of first when the word "rubber" is men-

tioned, namely, the tubes and tires. He reported the present production tube from GR-I, the isobutylene type, a fine job, commenting on the fact that since diffusion of air through butyl tubes is about one-tenth as fast as through natural rubber, the tires need air less often than pre-war tires; and it is entirely possible, regardless of the availability of natural rubber, that butyl rubber will remain in tubes.

Explaining that a tire is a much more complicated product than most people realize (over 200 materials, each with special function, being welded together with rubber in the creation of a modern tire) he stated that taking the over-all characteristics and serviceability of passenger car tires it can be safely said the better-developed casings today are as good, and in many cases better than the pre-war product.

As evidence of further efforts of the automotive engineer to provide the smoothest operating vehicle possible, Mr. Resseger mentioned the work done on rubber spring suspensions and the successful use of "torsilastic" springs on automobiles. He also mentioned that the present V-belts of American-made rubber are superior to the pre-war natural rubber product, after solution of problems presented by operation at high speeds and with excessive overloads, such solution effected by certain structural changes and the use of high heat-resisting rayon tension members. Finally in sealing the automobile against dirt and the elements, general purpose American-made rubber has also been found satisfactory.

Concluding, Mr. Resseger expressed pride in the talent and energy of those who had part in the development of man-made rubber, and who made possible the achievement of this modern miracle, meeting a vital need in so critical a period. He noted, however, that natural rubber is returning to world markets in an ever-increasing flood, and by the end of the year, the actual physical need for general-purpose American-made rubber may fall off very sharply. Commenting on this possibility, and subsequent possible cartel manipulation in reference to crude rubber, he felt there should be government adoption of a program assuring maintenance of the government's efficient facilities for manufacture of American-made rubber, ready to be run on immediate notice; and that sufficient tonnage of such rubber for maintenance of national security be made and used every year. In closing, he stated: "Beyond these provisions for security America's long-range rubber policy should be based on the principle of competitive enterprise. The free-play of economic forces will do more than anything else to spur research and development of all types of rubber to broaden their usefulness and to make more and better products available at lower costs."

Chicago District Participates in Production Conference

THE Chicago District of A.S.T.M. sponsored a panel at the Production Conference, held March 17, 18, and 19, by the Chicago Technical Societies' Council, covering the Forming of Metals under the chairmanship of D. L. Colwell, member and Program Chairman of the Chicago District Council.

The first paper presented was "Cold Heading and Forming of Steel," by Clarence K. Hayward, Russell, Burdsall & Ward Bolt and Nut Co., and covered the cold forming of steel wire into machine screws, bolts, and similar fastening parts. He discussed die materials and machine equipment, and had samples to illustrate the operations described.

A motion picture in color was presented by K. D. Waide, Aluminum Company of America, which described drawing, stretching, and stamping of aluminum, and gave information concerning the types of alloys used, and the respective advantages and disadvantages of each. He emphasized particularly the necessity for intermediate annealing treatments in deep drawing of sheet aluminum, especially in the harder alloys.

H. W. Butterbaugh, American Brass Co., Kenosha, Wis., presented the third paper, which described the brass alloys used in the extrusion and rolling of brass. He discussed particularly the effects of variable alloy contents and described the deterioration known as "season cracking," mentioning how it can be avoided. His series of samples illustrated the effects of composition variation in various steps of deep drawing operation.

Following presentation of the papers, there was discussion from the floor, with particular emphasis on the types of materials used in tooling up for the various processes described.

Officers of the Chicago District are J. J. Kanter, Crane Co., Chairman, J. de N. Macomb, Inland Steel Co., Vice-Chairman, and G. E. Stryker, Bell and Howell Co., Secretary.

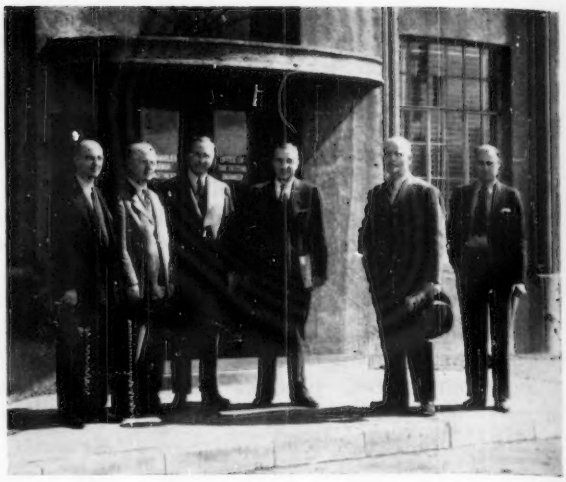
President and Secretary Visit Pacific Coast

THE PRESIDENT and Executive Secretary of the Society made a trip in March to the Pacific Coast, to meet with the members of the Society in the Northern and Southern California Districts, and especially to confer with the two District Councils on local activities.

Arriving in San Francisco on March 8, conferences were held with the officers of the Northern California District Council. On the evening of March 10, President Arthur W. Carpenter addressed a joint meeting of the members of the Society with the California Section of the American Chemical Society. The next evening the District Council met for discussion of numerous items of business, among the most important being plans for a meeting of the Society on the Pacific Coast in 1949. The Council had previ-

ously extended an invitation to the Board of Directors that such a meeting be held, and it was decided at the Council meeting to recommend that the meeting be held in San Francisco in October of 1949. On succeeding days there were visits to various industrial plants and to the University of California, as well as conferences on specific technical matters with various members of the Society. The Executive Secretary in particular looked into a number of questions relating to the proposed Society meeting in 1949.

The same general pattern of conferences and meetings was followed in the visit to Los Angeles extending from March 14 to 21. On Monday, March 17, the President and Secretary met with the Southern California District Council, and the next evening they addressed a joint meeting of Society members with The Los Angeles Rubber Group, Inc. Conferences with members included visits to the laboratory of the North American Aviation Corporation and to the Terminal Island Navy Yard and the Los Angeles Harbor. Conferences on technical activities of the Society included discussions with representatives of the aircraft industry and of the paint, rubber, and plastics industries.



President A. W. Carpenter and Executive Secretary C. L. Warwick Visit the Office of Testing Engineer of the Los Angeles Harbor Department. From *l.* to *r:* R. H. Pierson, Chemist, U. S. Naval Drydocks, Terminal Island: E. O. Slater, President, Smith-Emery Co.; Mr. Warwick; Mr. Carpenter; T. A. Fitch, recently retired from the Los Angeles Department of Standards, and a former Director of the Society; and C. M. Wakeman, Testing Engineer, Los Angeles Harbor Department. Messrs. Pierson, Slater and Wakeman are members of the Southern California District Council, and Messrs. Slater and Fitch are past chairmen.

Our members on the Coast extended an extremely cordial welcome to these two officers of the Society and did everything possible to facilitate the conferences which were held. It is very gratifying to note the keen interest of these members in the affairs of the Society and their desire to participate in the committee and other work of A.S.T.M. to the maximum possible extent. The continuing industrial growth in California is opening up many opportunities for extension of A.S.T.M. membership and activities in both the Northern and Southern California areas.

Brief accounts of the formal meetings addressed by President Carpenter follow.

Joint Meeting with The Los Angeles Rubber Group

A JOINT meeting of the members of the Southern California District of the Society with The Los Angeles Rubber Group was held on the evening of March 18 at the Rodger Young Auditorium in Los Angeles. About 150 persons attended the meeting and the dinner that preceded. Mr. R. B. Stringfield, Consulting Chemical Engineer, and Chairman of the Southern California District Council, presided, and introduced Mr. P. W. Drew, Goodyear Tire and Rubber Co., Vice-Chairman of the Los Angeles Rubber Group, who expressed the pleasure of their group in this first meeting with members of our Society.

The Executive Secretary, on invitation of the Chairman, outlined for the information of the rubber men present the nature of the Society and its work, with particular emphasis upon the development of standards and the broad scope of the Society's endeavors in that field. He referred to some of the technical subjects that had been discussed in recent months and are covered in special publications. A brief description was given of the extension of the Society's work into the field of simulated service testing and the testing of parts and assemblies, some phases of which are of particular interest to the rubber industry.

President Carpenter then addressed the meeting on "Progress in Rubber." In this talk he discussed to a limited extent the influence of research and standardization in industry, as he had done at the Berkeley meeting a week earlier, drawing illustrations principally from the war-time developments in petroleum and synthetic rubber production. He closed with special reference to progress along a number of lines in the rubber industry, discussing some of the newer applications of rubber-like materials and emphasizing improvements in quality of American-made rubbers which have already been realized. His remarks were enthusiastically received and the meeting closed with a spirited "question and answer" period.

Joint Meeting with California Section, American Chemical Society

ABOUT 250 members of the California Section, American Chemical Society and the Northern California District of A.S.T.M. joined in a meeting at the Claremont Hotel in Berkeley, on the evening of March 10. After a very enjoyable dinner at the hotel, Mr. Robert Matteson, of the California Research Corporation, Chairman of the A.C.S. Section, extended greetings to President Carpenter and Executive Secretary Warwick. After a brief response by Mr. Warwick, President Carpenter addressed the meeting on the subject "Progress in Chemical Industry Through Research and Standardization." His address, the text of which is pub-

lished elsewhere in this BULLETIN, was supplemented by a number of very interesting slides, illustrating some of the war-time developments in application of standardization to production in several of the important chemical industries. The address was well received and engendered an interesting discussion.

Society Participates in Western Metals Congress

UNDER the auspices of the Northern California District Council, the Society participated in the Exhibition of the Western Metals Congress held at Oakland, California, March 22–27, 1947, by having a booth provided by the American Society for Metals, sponsor of the Congress and Exhibition. The booth contained a display of literature about the Society and many of its technical publications, and served as headquarters for the members of the Society attending the Congress. The booth was manned continuously throughout the six days of the Congress by members of the Society.

A report by the Chairman of the District Council, Mr. Dozier Finley, indicates that during the week upwards of four thousand persons stopped at the booth to ask questions, examine literature, read the display signs, etc. Approximately twenty-four hundred pieces of literature were distributed and the names of a number of persons who might be interested in the Society and its activities were noted. Mr. Finley reports that the Council members feel the exhibit was valuabe in two ways—first, in creating new interests among those who are not yet acquainted with the Society and its work; and secondly, in building up a better acquaintanceship of our own members in the Pacific area with the conditions under which the Society serves engineering and industry.

Vice-President T. A. Boyd to Speak at Pittsburgh Meeting

THE SOCIETY'S Senior Vice-President, T. A. Boyd, Head, Fuel Department, Research Laboratories Division, General Motors Corp., Detroit, Mich., will speak at a meeting under the auspices of the Pittsburgh District at the Mellon Institute on Monday, May 19. His address will be entitled "Gasoline—Yesterday, Today, Tomorrow." The information and discussion which he will present will be of interest to all those concerned with the subject of automotive engineering and automotive fuels. Some of his data are startling, and throughout the address there is a sprinkling of humor. The question of how gasoline will meet the demands for its use, and the supply situation now and in the future, and also the relation of research and technology to this very important field are covered.

All members of the Society and any others interested are cordially invited by the Pittsburgh District Council to attend this meeting.

Past-President, Dean Harvey has arranged the technical program, and Messrs. J. J. Bowman and M. D. Baker, Pittsburgh District Chairman and Secretary, respectively, are responsible for the other details in connection with the meeting.

New York Meeting on Radar

The third and final meeting of the season sponsored by the New York District Council is to be held at the Engineering Societies Building, 29 W. 39th St., New York, in Room 501 on Tuesday, May 27 featuring interesting discussions and demonstrations on radar. The program, arranged by a committee headed by C. T. Hatcher, Consolidated Edison Co. of New York, Inc., is being prepared by the Signal Corps Branch of the U. S. Army with headquarters in New York. There will be a number of interesting illustrations, and a special 16-mm. film is scheduled for presentation.

The objective of this meeting is not to present details of all the technical ramifications of radar, but rather to present implications of this phenomenal development so that the meeting will be of interest to all technical men and engineers. The committee fully anticipates that an interesting and instructive meeting is in store.

The New York District officers, Messrs. Myron Park Davis, E. A. Snyder, and G. O. Hiers, Chairman, Vice-Chairman, and Secretary, respectively, will handle details in connection with the meeting.

TECHNICAL COMMITTEES

Shipping Container Standards Reviewed

A SOUND film presentation in technicolor covering the series of packaging container tests which have been adopted generally by the industry through the efforts of Committee D-10 on Shipping Containers, highlighted the meeting of this committee at the Franklin Institute in Philadelphia, Pa., on April 11. The film was prepared by the Owens-Illinois Glass Co. under the direct supervision of Dr. J. H. Toulouse, Chief Engineer of the Quality and Specifications Section and an active member of Committee D-10. In addition, Dr. Toulouse gave a graphic presentation of the application of statistical methods as they apply to shipping container test data and performance.

Included in the reports of the subcommittees, which met on the previous day at A.S.T.M. Headquarters, were recommendations for the advancement to standard of four tentative test methods: Compression Test (D 642); Drop Test (D 775); Revolving Drum Test (D 782); and Incline-Impact Test (D 880). These were approved for letter ballot with minor revisions in some cases. In the field of moisture and moisture vapor resistance, three proposed test methods were reported in varying stages of de-

velopment: the Test for Water Vapor Permeability of Packages has been accepted by the Society; the Test for Water Resistance of Containers (Spray Method) is in its final stage of approval by the subcommittee; and the Test for Water Resistance of Containers (Submergence Method) is now being drafted. Progress was reported on definitions being compiled and a bibliography covering the field of interior packing as used in shipping containers.

Four Construction Material Committees Hold Spring Meeting in Cincinnati

MUCH progress in the development of A.S.T.M. standards covering construction materials was reported at a three-day joint session of Committees C-1, C-9, D-4, and D-18 held at the Netherlands Plaza in Cincinnati, Ohio, March 26, 27, and 28. This grouping of meetings proved very advantageous due to the large percentage of overlapping membership on these committees. A total of 45 well-attended meetings were held during this period.

Committee C-1 on Cement met during the afternoon of March 28, with subcommittees having met on all three days of the session. Subcommittees presented progress reports on several significant phases of activity. Work is being started on a cooperative study designed to furnish information to aid in writing a durability specification for masonry cements. An investigation of a number of methods proposed for the determination of time of setting is under way. Effective steps have been taken to insure early work on an extensive investigation of questions relating to the SO_3 content of cements and, particularly, to the development of a satisfactory performance test to determine the optimum SO_3 content for a given cement. Methods of determining the air-entrainment of cements are receiving active study, and consideration is being given to a proposal that the air-content limits in C 175T be increased from 16 ± 4 per cent to 18 ± 3 per cent, and also to the suggestion that Types III, IV, and V cements be added to that same specification.

A special joint subcommittee of C-1 and C-9 is considering ways and means of financing a proposed expansion of the work of the Cement Reference Laboratory to include the inspection and checking of compression testing equipment. Action was taken approving recommendations on revision of several standards. Changes in the chemical requirements will result in the deletion of the aluminum and iron oxide ratio limits in the Standard Specification for Portland Cement (C 150) and Tentative Specification for Air-Entraining Portland Cement (C 175) as well as further changes in Type V cement. A significant recommendation pertained to the deletion of the tensile strength requirements from C 150. A proposed revision in the Tentative Specification for Portland Blast-Furnace Slag Cement (C 205) will permit the use of TDA in an amount not exceeding 0.08 per cent when grinding the cement. The Tentative Method for Determination of the Heat of Hydration of Portland Cement (C 186T) was recommended for advancement to standard.

Committee C-9 on Concrete and Concrete Aggregates met during the morning of March 28. Subcommittee meetings were held on March 26 and 27. The reorganization plan received final approval by the members present and, upon favorable letter ballot, will become effective immediately following the next meeting of the committee which will be held during the Annual Meeting of the Society. This plan, as described in an item appearing in the January BULLETIN, embodies the feature of combining subcommittees under Administrative, Research, and Test Method and Specification groups. The present subcommittee is authorized to function in setting up the actual committee organization and personnel. New proposed methods of test in varying stages of development include the Determination of Modulus of Elasticity (Sonic), Bleeding of Concrete and Strength of Bond (Pullout Test). In the field of admixtures, a new method of test of Evaluation of Admixtures of Concrete was proposed for publication in the ASTM BULLETIN for information only. Approval was given to the proposed revision of the Specification for Ready-Mixed Concrete (C 94) which centers around a provision for the use of non-agitating equipment for transporting concrete.

Committee D-4 on Road and Paving Materials met during the afternoon of March 27, with eleven subcommittee meetings held on March 26 and 27. A joint resolution of Committees D-2, D-4, and D-8 in memorial to Mr. C. N. Forrest was read and approved. The several subcommittee reports included numerous recommendations on existing standards. These included contemplated revisions of the Softening Point Test Method (E 28), the Los Angeles Abrasion Test Method (C 131), the Method of Test for Penetration of Bituminous Materials (D 5), and the Method of Test for Moisture-Density Relations of Soils (D 698T). New proposed standards receiving the attention of the committee include methods of tests covering the measurement of resistance to film stripping; and sand-rock asphalt. The adoption of the Burgraf Method on Shear Strength of Flexible Road Surfaces, Subgrades, and Fills and the proposed Method of Test for the Determination of Absorption, Expansion, and Strength Characteristics of Soil-Bituminous Mixtures were presented for adoption by the Joint D-4 and D-18 Subcommittee and were accepted. New specifications will be formulated covering asphalt cement, and hot-mix, hot-laid asphaltic concrete.

Committee D-18 on Soils for Engineering Purposes met during the morning of March 27, preceded by five subcommittee meetings on March 26. The new organization plan was adopted for submission to letter ballot, following considerable discussion on its operation. This plan is essentially the same as that adopted by Committee C-9. Announcement was made of the coming presentation of the Symposium on Load Tests as well as a session on other technical papers covering soils engineering to be given at the 1947 Annual Meeting. The Joint D-4 and D-18 Subcommittee presented recommendations on several standards including the adoption of the proposed Tentative Method of Test for the Determination of Absorption, Expansion, and Strength Characteristics of Soil-Bituminous Mixtures and the Burgraf Method on Shear Strength of Flexible Road Surfaces, Subgrades, and Fills. The reports of other subcommittees included recommendations on 7 existing standards, and a new tentative test method which covers the Field Determination of Density of Soils in Place.

Committee D-13 on Textile Materials Meets in New York City

Committee D-13 on Textile Materials held its spring meeting on March 12–14 at the Park-Central Hotel in New York City with an attendance of 235 members and guests. Sessions were held of twenty subcommittees and sections.

The meeting was featured by a symposium discussing the use of the electric strain gage for the tension testing of textiles, a comparatively recent development. The symposium was held on Thursday afternoon and comprised three papers describing the use of the gage in connection with instruments for measuring the strength and elongation of textile fibers and yarns. The first paper by Dr. J. W. Ballou of the Rayon Department, Technical Division, E. I. du Pont de Nemours & Co., Buffalo, N. Y., discussed the magnetic type of strain gage and its textile applications. Professor W. N. Murray, head of the Stress Analysis Laboratory, Engineering Department, Massachusetts Institute of Technology, Cambridge, Mass., discussed the wire resistance type of strain gage, and gave illustrations of typical applications of the instrument. Dr. Herbert W. Schiefer, Chief Physicist, Textile Division, National Bureau of Standards, Washington, D. C., discussed indirect methods applicable to the use of both the magnetic and resistance strain gages to textile testing.

The Subcommittee on Cotton and Its Products submitted several important revisions in the Tentative General

Methods of Testing Cotton Fibers (D 414). The revisions comprise the inclusion of a flat bundle method for determining the tensile strength and the omission of the round bundle test procedure for fiber strength, and also the inclusion as an alternate procedure for determining immaturity by polarized light method. This latter procedure applies to thin-walled fibers in which the deposition of cellulose was arrested before the fiber reached normal wall thickness. The subcommittee also reported that further consideration is being given to an optical method, using an instrument known as the fibrograph, for measuring the length and uniformity of a sample of cotton. The instrument is now being modified and, when production is resumed, the committee plans to make some recommendation regarding this method. Action was taken also on revisions in the Standard General Methods of Testing and Tolerances for Cotton Yarns (D 180).

The Section on Tire Fabrics submitted various revisions and additions to the Tentative Methods of Testing and Tolerances for Cotton Tire Cord (D 179), and for Rayon Tire Cord (D 885), as a result of information received from a canvass of manufacturers and users of tire cord.

The Section on Rayon took action on revisions in the Methods of Testing and Tolerances for Continuous Filament Rayon Yarns (D 258), for Spun Rayon Yarns and Threads (D 507), and for Rayon Staple (D 540).

The Section on Rayon Fabrics submitted a revision of the test for strength of rayon woven fabrics when wet. This section has also under consideration the need of specifications for blanket bindings. Consideration was also given to a revision of the method of test for colorfastness to atmospheric gases of dyed cellulose acetate rayon.

The Section on Wool reviewed data presented in a report of a special committee on shrinkage studies.

The Section on Woolen and Worsted Yarns considered revisions in the Methods of Testing and Tolerances for Woolen Yarns (D 403), and for Worsted Yarns (D 404).

The Section on Pile Fabrics considered at its meeting procedures for the evaluation of intangible factors of quality, methods of testing Kraft cord, standards for laboratory wear tests, and methods for determining flammability.

The Section on Asbestos Textiles reported considerations being given to revisions in the Specifications and Methods of Test for Asbestos Roving for Electrical Purposes (D 375) and for Asbestos Yarns (D 299); also that a method of test for asbestos lap is in preparation. Consideration is being given to combining the standards for asbestos and glass fabrics.

The Subcommittee on Bast and Leaf Fibers reported on results of round-robin interlaboratory tests on methods of extraction. The test results reported showed variations between laboratories greater than the expected experimental variations. The committee accordingly decided to make certain changes in the technique for making the tests and will make a further study of the method to determine if the revised procedure will give greater reproducibility in tests between laboratories.

The Subcommittee on Methods and Machines held a very interesting meeting at which two papers were presented describing studies of various types of clamps used in testing textile fabrics. One of these described the relationship of grip design to apparent cord strength.

The Subcommittee on Sampling, Presentation and Interpretation of Data received a report of its task group on a tentative outline of a suggested recommended practice for planning and conducting interlaboratory tests.

The Subcommittee on Nomenclature and Definitions reported the completion of definitions of terms dealing with fire tests of textiles such as combustible, flameproof, flame-resistant, flammable, noncombustible, nonflammable, etc., which are being recommended for publication as tentative. Action was taken to submit to letter ballot vote of the subcommittee definitions of velvet, plush, velour, frieze, boucle, and velveteen. The subcommittee also decided to recommend the adoption as standard of those definitions now published as tentative which have not been subject to any comment or criticism.

One of the most interesting sessions was that of the Special Committee on Abrasion, which group has been carrying on extensive studies of the Taber abraser, the Weizenbeek precision wear test meter, and the U. S. Testing Co. machine. Reports were received from the several task groups studying these several abrasion machines. This is a long-time program and studies are accordingly being continued.

Abrasive Properties of Finely Divided Solids

In the field of rotary drilling and centrifugal pumping, the abrasive effect of finely divided solids in suspension is a serious problem. The erosion of concrete spillways and dams by solids in flowing water is another illustration of this destructive effect. In many instances, finely divided mineral matter—0 to 44 micron particle size—such as barite, bentonite, fullers' earth, and ordinary clays and sands, have almost eliminated the use of centrifugal pumps due to the excessive rate of wear on the equipment.

The Society has received an inquiry from one of its members as to whether any group in the Society had developed or is interested in developing a method of test for determining the abrasive properties of finely divided solids. An expression of interest in the need for such a study or of the knowledge of existing data is desired by the Technical Department. All correspondence should be addressed care of the Technical Secretary.

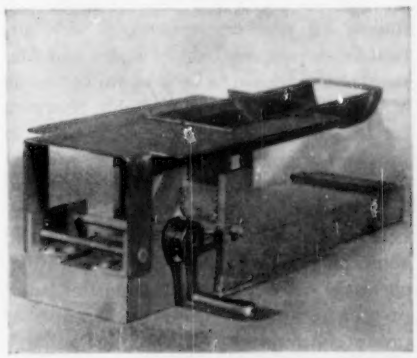
Sand Color Plate Replacement

All users of A.S.T.M. Standard Method of Test for Organic Impurities in Sand for Concrete (C 40), 1946 Book of Standards, Part II, page 466, who consider the present color chart unsatisfactory for use in determining the proper classification of fine aggregate samlpes in the standard color solution, are invited to request a replacement by writing Society Headquarters.

A supply of the older reproductions of the charts, which are considered satisfactory, is available for this purpose.

Shield for Burmister Flow Trough

Early use with the Burmister flow trough in determining the air content of portland cement mortar by A.S.T.M. Tentative Method C 185 showed the need for protecting the surface of the cam and steel plate of the trough and the pivotal shaft and its side seats from grit shaken loose in operation. To provide the necessary protection, now suggested in Note 2 of Tentative Method of Test for Air Content of Portland Cement Mortar, A.S.T.M. Designation C 185–46 T, E. L. LeBay, Engineer, and Roy Boyes, Assistant in the Cement Section, of the Ohio State Highway Testing and Research Laboratory designed, and the Laboratory Machine Shop constructed, the shield shown in the accompanying photograph. Adding the shield to the Burmister flow trough is a simple operation.



A Thought

"A nation is made great, not by its fruitful acres, but by the men who cultivate them; not by its great forests, but by the men who use them; not by its mines, but by the men who build and run them. America was a great land when Columbus discovered it; Americans have made it a great nation."
—Lyman Abbott.

Society Receives Howe's Book on "The Metallurgy of Steel, 1890"

THROUGH the generosity of H. E. Smith, a long-time active member and honorary member of A.S.T.M., who has made many important technical contributions to work in materials, the Society has recently received a copy of the famous publication "The Metallurgy of Steel" by Henry Marion Howe. Issued in 1890, this notable book has had a great influence throughout industry, and we are pleased to have the publication for our library. Very few, if any, scientists or engineers have surpassed Howe's ability to write trenchantly and at the same time to express the exact shades of meaning he wished to convey. To those who have had occasion to refer to the book, no description of it is necessary, and for those who have not seen it we can only suggest that if there is an occasion the book is worthy of study, even if only briefly. The copy at Headquarters can be referred to by any of the members at any time.

One might ponder on some of the present-day publications with respect to the tabular data and other information used, in comparison with Howe's pioneer efforts. Of the 200 tables in the volume, all but 20 small ones were wholly original or calculated by him from information which was obtained from other sources than his own profound knowledge.

It is interesting to note that this 400-page book, page size 10½ by 13 in., was listed at $10. We would hesitate to hazard a guess on the selling price of a volume issued today which would be equivalent in inherent technical value.

The New Fibers

TEXTILE technologists and indeed all who are concerned with the rapidly developing field of fibers and filaments have reason to be grateful to Joseph V. Sherman and Signe Lidfeldt Sherman for their book on "The New Fibers." It provides in one volume information about the many new synthetic fibers, new and improved rayons, and improved natural-fiber textiles. The history, chemical composition, method of preparation, chemical and physical properties, and present and potential uses of each fiber or product are given. Trends in research are indicated. Statistical information on the production, consumption, and prices of cotton, wool, silk, rayon, and some of the synthetics is presented. The competitive position and future prospects of both natural and manufactured fibers are analyzed dispassionately. Each chapter ends with a list of references to the literature. A valuable feature of the book for some workers is the classified list of approximately 1600 patents on the new fibers issued in the United States during the past 10 years. Over one-fourth of the 521 pages of the book is devoted to this list. The authors acknowledge the cooperation of 20 well-known experts, 39 leading manufacturers and associations, and several government agencies.

Following the introduction and a general comparison of the properties of the fibers, chapters are devoted to nylon; to fibers made from vinyl resin, vinylidene chloride, glass, polyethylene, other synthetics, casein, soybean protein, other proteins; to improved rayons, rayon staple fiber, the economic aspects of rayon, and new cellulosic fibers. A chapter on miscellaneous new fibers discusses briefly metal yarns and monofilaments, fibers made from alginic acid from seaweed, a new type of asbestos-cotton textile, ramie, cattail, milkweed fiber, chicken feather fiber, and redwood bark fiber. One chapter is devoted to chemical treatments for textiles including chemical modifications of fibers and fabrics, impregnated and coated yarns and fabrics, and bonded web fabrics. Another chapter is made up of a list of applications suggested for the new fibers and an index to trade names of fibers.

Scientific and technical readers might like more facts about some of the materials treated in this book and a more critical evaluation of the test data. No doubt the authors would have liked to provide this information and would have done so if it were available. The book is well written, well printed, and seems to be exceptionally free from errors.

The publisher is D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y., and the price of the book is $5 per copy.

W. D. APPEL

British Petroleum Publications

THE NEW 1947 (eighth edition) of the Standard Methods for Testing Petroleum and its Products as published by the British Institute of Petroleum has been received and A.S.T.M. members and others in the United States who find it convenient to procure the publication from A.S.T.M. Headquarters may do so. This eighth edition is considerably enlarged with a number of new and revised standards.

The new methods include procedures for the estimation of metals in unused lubricating oils, examination of the tendency of grease to corrode copper, determination of the flash-point of liquid asphaltic bitumen, examination of the resistance to oxidation of turbine oils, and a modification of the Schwartz method for estimation of tetraethyl lead in motor fuel.

Among the subjects covered by revised methods are the following: Aniline Point, Burning Test for Kerosene, Carbon Residue (Conradson Method), Carbon Disulfide in Petroleum Products, Demulsification Number of Lubricating Oil, Flash-Point (Open) and Fire-Point by means of the Cleveland Apparatus, Free Alkali (including Carbonates) and Free Acid in Greases, Gum (Existent) in Motor Fuels, etc., Hydrogen Sulfide, Knock-Rating of Aviation Fuels (Weak Mixture), Knock-Rating of Motor Fuel, Peroxide Value of Ethers, Viscosity (Kinematic) in Absolute Units, Wetting Power of Wetting Agents Derived from Petroleum.

This publication now covers some 640 pages. In addition to the large number of British methods and specifications it includes the personnel of the committee responsible for the work and other information. Copies can be obtained from A.S.T.M. Headquarters at $4.00.

In January, 1946, there was an announcement in the BULLETIN of the publication of Tables for Measurement of Oil, which 320-page book is essentially the official British counterpart of the United States Bureau of Standards Circular C410. This book has been found particularly useful in many branches of the industry. A small stock of the books is being maintained at A.S.T.M. Headquarters. It can be procured at $6 per copy.

The address of the British Institute of Petroleum is Manson House, 26 Portland Place, London, W.I.

Contributions to Soil Mechanics—1925–1940

AN INTERESTING collection of articles on the subject of Soil Mechanics, published originally in issues of the *Journal* of the Boston Society of Civil Engineers, dating back to December 1925, is presented in this book. The leadoff and earliest article was written by Dr. Charles Terzaghi, then Head of the Department of Civil Engineering at Robert College, Constantinople, and Special Lecturer on Foundation Engineering at the Massachusetts Institute of Technology. Dr. Terzaghi is generally recognized as the first to introduce the subject of "Soil Mechanics" into this country. Since then the Boston Society of Civil Engineers has sponsored this important phase of engineering by giving a prominent place in their *Journal* to articles on this subject by Dr. Terzaghi, and to other prominent research men who have carried on and advanced the good work which he started.

These articles are published in their original form, and the book is not intended as a textbook on the subject of Soil Mechanics. The articles are, in general, highly technical in nature, and it is recognized that further advancement in this field may

mean that in some respects they will not correctly reflect modern beliefs.

The coverage is extensive, including foundation engineering as related to concrete roads, the importance of study of clay structure, and the application of theories of elasticity and plasticity. Two articles cover the mechanics of hydraulic-fill dams and seepage through dams. The shearing resistance of soils and the characteristics of cohesionless soils are very carefully reviewed. Developments in soil testing apparatus are covered up to 1935, the date of this particular paper. Among several other articles is a very methodical development of the fundamentals of dynamic pile driving formulas.

Compiled and published by the Boston Society of Civil Engineers, the book is available at $2.25 per copy, from 715 Tremont Temple, Boston 8, Mass.

Manual of Design for Arc Welded Steel Structures

THE Manual of Design for Arc Welded Steel Structures recently published by the Air Reduction Sales Co. fills a need often expressed by practising engineers and engineering educators for a comprehensive source of up-to-date information to facilitate the rapid design of welded steel structures and provide a suitable supplementary text for engineering students. Although many features of the book have been compiled particularly for use in building construction, many of the design diagrams and fundamental principles may be applied to the design and engineering control of other types of welded steel construction. Compiled by LaMotte Grover, who is active in A.S.T.M. work, and in the A.S.C.E. and is well known in the field of structural welding, the methods and procedures presented are based chiefly upon standards of the American Welding Society, the 1946 edition of the Specifications of the American Institute of Steel Construction, and reports of the Welding Research Council's Structural Steel Committee. One outstanding feature of the manual is a set of 26 diagrams for the rapid proportioning of weld-groups and connections subjected to eccentric loading. Another prominent feature is a complete set of beam safe-load tables. Rather comprehensive discussions are included covering the estimating of costs of welded construction and the inspection of structural welding, together with references to more comprehensive treatises upon inspection.

Copy of this 285-page manual, with its diagrams, tables and data, compiled in convenient reference form for engineers in this field, may be obtained from Air Reduction Sales Company, 60 E. 42nd Street, New York 17, N. Y., at the price of $2.

American Institute of Physics

DR. GEORGE R. HARRISON, Dean of the School of Science, M.I.T., has been elected Chairman of the American Institute of Physics, succeeding Dr. Paul E. Klopsteg, Director of Research, Northwestern University Technological Institute, who has served as Chairman since 1940. Under Dr. Klopsteg's chairmanship the Institute was recently reorganized and changed from a loose federation of the leading national societies in the field of physics to a membership organization. It is now composed of the American Physical Society, the Optical Society of America, the Acoustical Society of America, the Society of Rheology, the American Association of Physics Teachers, and about 9000 individual members. New members of the Governing Board of the Institute are: Dr. Harrison; Dr. E. U. Condon, Director, National Bureau of Standards; Dr. A. J. Dempster, Argonne National Laboratory; and Dr. Marsh W. White, Pennsylvania State College.

In connection with the new Institute publication Dr. Harrison said: "There is an urgent need for a new journal of general interest which gleans material from all branches of physics and reports it to all physicists, to other scientists, and to engineers and others interested in physics. It is such a journal which the Institute of Physics plans to launch within the next few months.

"The new journal will serve two major purposes: It will foster cooperation among physicists, and strengthen the feeling of unity in a large profession composed of diverse specialists; and it will inform other scientists and laymen of the most important new developments in one of our most fundamental sciences."

About one-third of the funds required to finance the new publication until it can become self-supporting have been raised by the Institute, principally from industrial companies which are based on physics.

To the A.S.T.M. Committee on Membership, 1916 Race St., Philadelphia 3, Pa.

Gentlemen:

Please send information on membership to the company or individual indicated below.

_____

_____

This company *(or individual)* is interested in the following subjects: *(indicate field of activity, that is, petroleum, steel, non-ferrous, etc., etc.)*

_____

*(Signed)*_____

Date_____ Address_____

Errata in Book of Standards I-A and I-B

IN ADDITION to some errors and changes which should be noted in specifications in Part I-B, Non-Ferrous Metals, of the 1946 Book of Standards, a few additional items have come to light, and there are a number of changes which should be noted in Part I-A, Ferrous Metals. Some of these resulted from errors in printing and a few are not of great significance but it would be well if our members would note in their books *all* of the changes

PART I-A

page 1—Specifications A 7 – 46.—In Section 2(*a*), second sentence, change the reference to "grade B-1 castings" to read "grade 65 – 35 castings."

page 42—Specifications A 285 – 46.—In Table II change all the values for elongation in 8 in. for flange steel to read 1,500,000 divided by the tensile strength, and for firebox steel, 1,550,000 divided by the tensile strength.

page 66—Specifications A 203 – 46.—In Table II change footnote *c* to refer to Section 7(*f*).

page 74—Specifications A 204 – 46.—In Section 12(*a*) change the value "00.1 in." to read "0.01 in."

page 235—Specifications A 237 – 46.—In Table I, for class D forgings, insert values of "50" under reduction of area, for both sizes listed.

page 261—Specifications A 186 – 46.—In Table I, for the minimum hub wall thickness for bores over 7 in., change the value "$1\frac{1}{4}$" to "$1\frac{1}{8}$."

page 282—Specifications A 252 – 46.—In the note below Table I change the formula for grade 1 from "$E = 56t + 17.50$" to "$E = 48t + 15$."

page 344—Specifications A 161 – 46.—In Table II delete the words "Wall Thickness" above the two columns "Specified Wall Thickness, per cent" and "Calculated Weight per Foot, per cent."

page 355—Specifications A 179 – 46.—In Table I add a footnote letter *a* after "Wall Thickness, per cent" and add the following under the table as footnote *a:* "For tubes having an inside diameter less than 60 per cent of the outside diameter or having a wall $\frac{3}{4}$ in. or over in thickness, which cannot be successfully drawn over a mandrel, the inside diameter may vary by an amount equal to plus or minus 10 per cent of the wall thickness. The wall thickness of these tubes may vary plus or minus 12.5 per cent from that specified.

"For tubes having an inside diameter less than $\frac{1}{2}$ in. which cannot be successfully drawn over a mandrel, the wall thickness may vary plus or minus 15 per cent from that specified; and the inside diameter will be governed by the outside diameter and wall thickness variations."

page 367—Specifications A 200 – 46.—In Table III delete the words "Wall Thickness" above the two columns "Specified Wall Thickness, per cent" and "Calculated Weight per Foot, per cent."

page 373—Specifications A 199 – 46.—In Table III add a footnote letter *a* after "Wall Thickness, per cent" and add a footnote as described above for insertion on page 355 for Specifications A 179 – 46.

page 374—Specifications A 199 – 46.—In the note in Section 15 change "Table II" to read "Table III."

page 446—Specifications A 194 – 46.—In Section 13(*c*) change the reference to "American War Standard for Screw Threads for High Strength Bolting (ASA No.: B1.4–1945)" to read "American Standard for Wrench-Head Bolts and Nuts and Wrench Openings (ASA No.: B18.2–1941)."

page 593—Specifications A 48 – 46.—In Section 2 change the reference to "Notes 1, 2, and 3" to read "Notes 1 and 2."

In Section 3(*b*) change the reference to "Note 4" to read "Note 3."

page 594—Specifications A 48 – 46.—In Section 4 change the reference to "Note 5" to read "Note 4."

In Section 6 change the reference to "Notes 6 and 7" to read "Notes 5 and 6."

page 754—Specifications A 283 – 46T.—In Table I change all the values for elongation in 8 in. to read "1,500,000 divided by the tensile strength." Change footnote *a* to read "See Sections 6(*d*) and (*e*)." Delete footnote letter *b* after "Elongation in 2 in., min., per cent," add the footnote letter *b* after the grade A value for elongation in 8 in. and change footnote *b* to read "See Section 6(*f*)."

In Section 6(*e*) add the phrase "in 8 in." after the words "percentage of elongation."

page 759—Specifications A 284 – 46T.—In the table of physical properties in Section 7(*a*) change the two values for elongation in 2 in. to read 1,600,000 divided by the tensile strength.

page 871—Specifications A 27 – 46T.—Under Section 1(*b*) add "65 – 30" in the fourth paragraph to the grades 60 – 30, 65 – 35, and 70 – 36 listed as required to be heat treated.

page 872—Specifications A 27 – 46T.—In Note 3 change the word "four" to "five" as the number of grades required to be physically tested.

page 912—Specifications A 106 – 46T.—Transpose the table in the note following Section 13(*a*) so that it follows the last line of Section 13(*b*).

page 919—Specifications A 158 – 46T.—In Table I, grade P11, add the word "max." after the value of 0.15 in the line opposite carbon content.

page 973—Specifications A 193 – 46T.—in Table II, opposite grade B 7*a* material over $2\frac{1}{2}$ to 4 in. in diameter, the 1200 F. heat treatment appears in bold face type. The value of 1200 should be in light face type as this heat treatment does not represent the standard heat treatment to be given material stocked for use under the specification, as implied by the bold face type.

PART I-B

page 509—Specifications B 143 – 46T.—In Section 1 delete the reference to footnote 3 after the word "alloys." Delete footnote 3 relettering the subsequent footnotes and their references accordingly.

page 551—Specifications B 26 – 46T.—Change the fourth line of Section 7(*b*) to be the second line of Section 7(*a*).

page 577—Specifications B 178 – 46T.—In Table II insert a value of 0.125 in. for plate with a thickness of 2.750 to 2.251 in. and a width of over 102 to 132 in.

To the A.S.T.M. Committee on Membership

1916 Race St., Philadelphia 3, Pa.

Gentlemen:

Please send me information on membership in A.S.T.M. and include a membership application blank.

(Signed)_____

Address_____

Date_____

New Members to April 18, 1947

The following 97 members were elected from February 28 to April 18, 1947, making the total membership 6273.

Names are arranged alphabetically—company members first, then individuals.

Chicago District

INDIANA STEEL PRODUCTS CO., THE, C. A. Maynard, Chief Engineer, 700 Valparaiso St., Valparaiso, Ind.

SILVERSTEIN & PINSOF, INC., Oscar M. Pinsof, Vice-President, 1720 Elston Ave., Chicago 22, Ill.

COMPTON, WENDELL COOPER, Assistant Chief Engineer, Miles Laboratories, Inc., Elkhart, Ind.

ISENBERG, N., Chief Chemist, Coke Plant, Inland Steel Co., East Chicago, Ind.

SMITH, PAUL H., Engineer of Tests, Chicago, Burlington & Quincy Railroad Co., Aurora, Ill.

TUTTLE, C. W., Senior Service Metallurgist, Carnegie-Illinois Steel Corp., 208 S. LaSalle St., Chicago 90, Ill.

Cleveland District

FERGUSON CO., H. K., THE, F. W. Daniels, Chief Engineer, The Ferguson Bldg., Cleveland 14, Ohio.

PATTERSON-SARGENT CO., THE, W. O. Hose, General Superintendent, 1325 E. Thirty-eight St., Cleveland 14, Ohio.

SELLEN, C. A., Chief Metallurgist, Eaton Manufacturing Co., Reliance Division, Massillon, Ohio.

SILLIMAN, W. A., Chief Metallurgist, The Oliver Corp., 19300 Euclid Ave., Cleveland 17, Ohio.

SIMMERS, CHARLES F., Assistant Chief Design Engineer, Carnegie-Illinois Steel Corp., 912 Salt Springs Rd., Youngstown, Ohio.

Detroit District

GENERAL MOTORS CORP., PROCESS DEVELOPMENT SECTION, C. G. Chambers, Engineer, Manufacturing Bldg., Cadillac Motor Car Division, 2860 Clark Ave., Detroit 10, Mich.

COOK, L. D., Materials Engineer, Research Dept., Wyandotte Chemicals Corp., Wyandotte, Mich.

DESOUZA, HENRY WILSON F., Captain, Brazilian Army, Ordnance Dept., Rio de Janeiro, Brazil. For mail: 417 E. Liberty St., Ann Arbor, Mich.

FREEMAN, J. W., Research Engineer, Department of Engineering Research, University of Michigan, Ann Arbor, Mich.

HUBBELL, GEORGE EDGAR, Consulting Engineer, 2640 Buhl Bldg., Detroit 26, Mich.

MARLOW, DAVE IAN, Design Engineer, Wyandotte Chemicals Co., Biddle Ave., Wyandotte, Mich. For mail: 31 Superior Blvd., Wyandotte, Mich.

WAGNER, HARVEY A., Senior Engineer, Mechanical Engineering Division, The Detroit Edison Co., 2000 Second Ave., Detroit 26, Mich.

New England District

UNITED STATES GUTTA PERCHA PAINT CO., Wayland W. Rice, Vice-President, Box 1365, Providence, R. I.

COLLYER, HARRY JAMES, Head, Rubber Testing Group, Godfrey L. Cabot, Inc., 49 Beach St., Boston, Mass.

KENNEDY, LUCIE C., MRS., In Charge of Laboratory, Jones, Gardner & Beal, Inc., 244 Thayer St., Providence, R. I. For mail: Box 1493, Providence, R. I.

LINBERG, GEORGE O., Sales Manager, Monsanto Chemical Co., Textile Chemical Dept., 140 Federal St., Boston, Mass.

New York District

DREW AND CO., INC., E. F., E. I. Valko, Director of Research, 416 Division St., Boonton, N. J.

GENERAL CERAMICS AND STEATITE CORP., William Contardi, Ceramist, Keasbey, N. J.

GRAY AND CO., WILLIAM S., D. R. Chamberlain, Secretary, 342 Madison Ave., New York 17, N. Y.

SUN CHEMICAL CORP., William S. Hodgkiss, Analytical Group Leader, 100 Sixth Ave., New York 13, N. Y.

U. S. SIGNAL CORPS, ENGINEERING LABORATORIES, Transportation Officer, Bradley Beach, N. J.

COHEN, CHARLES A., Supervisor, Chemical Research, Standard Oil Development Co., Chemical Division, Elizabeth, N. J.

KELLOGG, HUDSON W., Testing Coordinator, Ethyl Corp., 1060 Nepperhan Ave., Yonkers 3, N. Y.

KENT, MICHAEL, Textile Technician, Manville Fabrics, Inc., 16 E. Fortieth St., New York, N. Y. [J]*

LOBAUGH, FRANK E., Technical Service Manager, Lumnite Division, Universal Atlas Cement Co., 135 E. Forty-second St., New York 17, N. Y.

MAGLIO, M. MARTIN, 227 E. Thirty-fourth St., Brooklyn, N. Y.

NUGEY, ANTHONY LEON, Consulting Chemical and Mechanical Engineer, 1271 Pierpont St., Rahway, N. J.

PORT OF NEW YORK AUTHORITY, THE, J. C. Evans, Chief Engineer, 111 Eighth Ave. New York 11, N. Y.

SIMON, ALLEN C., Technical Director, The H. O. Canfield Co., 129 Housatonic Ave., Bridgeport, Conn.

STEFANELL, RENALDO, Electrical Technical Designer, American Institute of Electrical Engineers, Box 125, Station X, New York 54, N. Y.

Northern California District

HALES, ALBERT J., President, A. J. Hales and Co., Inc., 959 Thirty-second St., Oakland 8, Calif.

LEIBOLD, FRANK A., Jr., Chief Chemist, The Sherwin-Williams Company of California, 1450 Sherwin Ave., Oakland 8, Calif.

PADHI, ANANDA CHANDRA, Graduate Student, College of Engineering, University of California, Berkeley, Calif. For mail: International House, Berkeley 4, Calif. [J]

SOLNAR, GEORGE E., JR., Manager, Clay Brick Manufacturers Assn. of Northern California, 524-116 New Montgomery St., San Francisco 5, Calif.

Philadelphia District

ALCO OIL AND CHEMICAL CORP., O. B. Hager, Director of Research, Trenton Ave. and Williams St., Philadelphia 34, Pa.

CIBA CHEMICAL LABORATORIES, INC., S. N. Glarum, Chemist, Kimberton, Pa.

HARDWICK & MAGEE CO., Paul A. Endriss, Chemist, 650 W. Lehigh Ave., Philadelphia 33, Pa.

MASLAND DURALEATHER CO., THE, Irving Schmitt, Chemist, Amber and Willard Sts., Philadelphia 34, Pa.

BAIRD, KENNETH E., Chief Chemist, Philadelphia Coke Co., 4501 Richmond St., Philadelphia 37, Pa.

McDOWELL, SAMUEL C. T., Chemist, Houghton & McDowell, Inc., Box 301, Wilmington 99, Del. [J]

OWEN, W. WYCLIFFE, Textile Engineer, E. I. du Pont de Nemours and Co., Inc., Rayon Division, Wilmington 98, Del.

TAYLOR, GEORGE, Physicist and Chemist, Taubmans, Ltd., St. Peters, N.S.W., Australia. For mail: 2124 Land Title Bldg., Philadelphia 10, Pa.

Pittsburgh District

BROSKY, JOHN JOSEPH, Student, Grove City College, Grove City, Pa. For mail: 106 Spruce St., Grove City, Pa. [J]

BROSKY, STANLEY A., Department Head of Radiography, Pittsburgh Testing Laboratory, Stevenson and Locust Sts., Pittsburgh 19, Pa.

BRUNOT, JOHN B., JR., Superintendent, Pipe Dept., Pittsburgh Tube Co., Monaca, Pa. For mail: Box 154, Monaca, Pa.

FEELY, H. M., JR., Chief Engineer, Pittsburgh Tube Co., Monaca, Pa. For mail: 1817 Pennsylvania Ave., Monaca, Pa.

PIELAN, PAUL F., Highway Engineer, Koppers Co., Inc., Tar Products Division, Box 7372, Pittsburgh 13, Pa.

Southern California District

BAKER OIL TOOLS, INC., W. S. Althouse, Jr., Chief Production and Tooling Engineer, Box 2274, Terminal Annex, Los Angeles 54, Calif.

HILKERT, RALPH V., Chief Metallurgist and Assistant Director of Research, Solar Aircraft Co., Technical Research Div., 2200 Pacific Highway, San Diego, Calif.

HOLMAN, EMMETTE R., Chief Chemist, Turco Products, Inc., Box 2649, Terminal Annex, Los Angeles 54, Calif.

Western New York and Ontario District

HOGAN, GERALD L., Chief Inspector, John Inglis Co., Ltd., Toronto, Ont., Canada. For mail: 67 Gloucester St., Apt. 9, Toronto, Ont., Canada.

PARKER, W. E., Assistant Testing Engineer, Hydro-Electric Power Commission of Ontario, 620 University Ave., Toronto, Ont., Canada.

SCHOENFELDT, A. F., Assistant General Superintendent, Buffalo Bolt Co., 101 East Ave., North Tonawanda, N. Y.

U. S. and Possessions

CINCINNATI TESTING AND RESEARCH LABORATORIES, Elmer P. Warnken, Director, 308 W. Fourth St., Cincinnati, Ohio.

DAVIS PAINT CO., Willard W. Vasterling, Technical Director, Kansas City, Mo.

DAYTON POWER AND LIGHT CO., THE, Fred M. Reiter, Material Research Engineer, 25 N. Main St., Dayton 1, Ohio.

LINCOLN INDUSTRIES, INC., S. T. Harris, Manager, Plastics Division, Damascus, Va.

BLITZ, BAXTER S., Plant Engineer, American Cyanamid Co., Willow Island, W. Va. For mail: St. Marys, W. Va.

BROOKS, DONALD B., Chief, Automotive Section, National Bureau of Standards, Washington 25, D. C.

DANNER, ELLIS, Assistant Professor of Civil Engineering, Civil Engineering Dept., University of Illinois, Urbana, Ill. For mail: 201 Engineering Hall, University of Illinois, Urbana, Ill.

ENGELLAND, GEORGE, Chief Chemist, The National Refining Co., Findlay, Ohio.

FOWLER, ALBERT C., Chief Chemist, Huron Portland Cement Co., Alpena, Mich.

JOHNSON, A. W., Soils and Foundation Engineer, Highway Research Board, National Research Council, 2101 Constitution Ave., Washington 25, D. C.

LARSEN, S., Sales Engineer, T. L. Herbert & Sons, 174 Third Ave., North Nashville 3, Tenn.

LINCOLN, FRANCIS B., 4610 Drexel Rd., College Park, Md.

MORAN, WILLIS T., Chief, Chemical Engineering Section, U. S. Bureau of Reclamation, Denver, Colo.

MORGENTHAU, WILLIAM, Clark Equipment Co., Buchanan, Mich.

REED, RAMSEY M., Sales Service Engineer, U. S. Pipe and Foundry Co., 1711 First National Bldg., Birmingham 3, Ala.

SEN, BIDHU RANJAN, Assistant Engineer, Public Works Dept., United Provinces, India; Graduate Student, Department of Civil Engineering, Iowa State College, Ames, Iowa.

TRUSLER, R. B., Director of Research, The Davies-Young Soap Co., 400 N. Findlay St., Dayton 1, Ohio.
WILLIAMS, THOMAS, Co-Partner, Northwest Testing Laboratories, 2nd Ave. and James St., Seattle 4, Wash.

Other than U. S. Possessions

CANADIAN BRONZE CO., LTD., James G. Dick, Chief Chemist and Metallurgist, 999 Delorimier Ave., Montreal, P. Q., Canada.
DOMINION TEXTILE CO., LTD., H. Butterworth, Fabric Designer and Analyst, 710 Victoria Square, Montreal 1, P. Q., Canada.
CANTERBURY UNIVERSITY COLLEGE, ENGINEERING DEPARTMENTAL LIBRARY, Christchurch, C. 1, New Zealand.
COLLEGE OF AERONAUTICS, Robert L. Lickley, Professor, Cranfield, Bletchley, Bucks., England.
DIRECCION GENERAL DE AVIACION NAVAL, MINISTERIO DE MARINA, Moreno 1921, Buenos Aires, Argentina.
DIRECCION GENERAL DE AVIACION NAVAL, MINISTERIO DE MARINA, Moreno 1921, Buenos Aires, Argentina.
GHARPURE, BHASKER VISHVANALH, Curator, Lord Reay Industrial Museum, Poona, Bombay, India.
HARVEY, ROBERT P., Chief Chemist, Commercial Laboratories, Ltd., 5 Lett St., Ottawa, Ont., Canada. [J]
HUTNICZY INSTYTUT BADAWCZY, Michal Smiaowski, Director, Miarki 12, Gliwice, Poland.
LABORATORIO CENTRAL PARA ENSAYOS DE MATERIALES DE CONSTRUCCION, Eduardo Torroja, Director, Alfonso XII—3 Madrid, Spain.
LAMOUREUX, GERARD J., Assistant Manager, Usines Emile Henricot, Court-Saint-Etienne, Belgium.
LINDSAY, GUY A., Engineer in Charge, General Engineering, Department of Transport, Ottawa, Ont., Canada.
METALLOGRAFISKA INSTITUTET, C. Georg Carlsson, Metallurgical Engineer, Drottning Kristinas vag 48, Stockholm, Sweden.
NATAL UNIVERSITY COLLEGE LIBRARY, Herbert Coblans, Librarian, Box 1525, Durban, South Africa.
RIDER, G. E., Civil Engineer, Hydro Electric Commission, Tasmania. For mail: Butter's Gorge, Tasmania. [J]
RODRIGUEZ, ERNESTO J., Chief Chemist, Diadema Argentina S. A. de Petroleo, KM. 2F, Comodoro Rivadavia, Argentina. For mail: Casilla de Correo 5298, Comodoro Rivadavia, Argentina. [J]
SOUTH AUSTRALIA, PUBLIC LIBRARY OF, Box 386-A, Adelaide, South Australia.
VAN NIEUWENBURG, C. J., Laboratorium voor Analytische Scheikunde, de Vries van Heystplein 2, Delft, Holland.
VEZELINSTITITUUT T. N. O. (GOVERNMENT FIBRE RESEARCH INST.), Mijnbouwstraat 16 A, Delft, Holland.
WOOD, N. MCKINNON, Griffin & Tatlock, Ltd., Kemble St., Kingsway, London, W.C. 2, England.

* [J] denotes Junior Member.

Personals . . .

. . .News items concerning the activities of our members will be welcomed for inclusion in this column.

FRANK ZELENY, who recently retired as Engineer of Tests, of the Chicago, Burlington & Quincy Railroad Co., after many years of service, has been a member of A.S.T.M. since 1913. Mr. Zeleny plans to spend most of his time at his home, 824 Hardin St., Aurora, Illinois, although he will be spending a portion of each year in the Minnesota lake region. He expects to pursue that hobby which so many yearn for, namely, working in his vegetable and wild flower gardens, with Mrs. Zeleny assisting and concentrating on some phases of the flowering plants.

WILLIAM J. JEFFRIES, after 27 years with the Army and Navy, has retired from government service and is engaged in private practice as metallurgical consultant. His home is in Cape May, N. J.

THEODORE R. DONLAN, recently advanced to Solvent Specialist, Standard Oil Co. of N. J., Foreign Marketing Coordination, New York City, will be visiting foreign markets of the company in Europe, Africa, Central and South America, where he will survey for outlets, instruct sales, and establish solvent service units. Mr. Donlan, who is an active member of several A.S.T.M. committees, hopes to utilize A.S.T.M. test methods wherever possible in the foreign territory of the company.

The Cadman Memorial Medal of the Institute of Petroleum has been awarded to Robert P. Russell, President of STANDARD OIL DEVELOPMENT CO., which organization for many years has been very active in A.S.T.M. through its technical representatives. In connection with the award of the medal Mr. Russell will deliver the second Cadman Memorial Lecture in London on "Progress in Petroleum Research."

At the annual meeting of the Cleveland Technical Societies Council the principal address was delivered by Dr. Howard E. Fritz, Vice-President in Charge of Research, of the B. F. Goodrich Co.

WILLIAM W. MOORE, member of the engineering firm of Dames & Moore, San Francisco, has been elected President of the Structural Engineers Association of Northern California.

E. O. DIXON, Chief Metallurgical and Mechanical Engineer, Ladish Co., Cudahy, Wis., has been appointed a member of the National Metals Handbook Committee of the American Society for Metals.

LOUIS J. ROHL, formerly Chicago District Metallurgical Manager for Carnegie-Illinois Steel Corp., has been promoted to Assistant Chief Metallurgical Engineer at the Pittsburgh Office of the corporation.

OSCAR MAAG, Chief Chemist, Timken Roller Bearing Co., Canton, Ohio, has been elected President of the American Society of Lubrication Engineers.

HENRY R. POWER, formerly Chief Chemist, has been promoted to Manager of Laboratories, Carborundum Co., Niagara Falls N. Y. Mr. Power has been an A.S.T.M. member since 1916.

ARTHUR SCHRODER, formerly Executive Director AIC, has returned to the government service as Research Administrator for Chemistry in the Industrial Research and Development Division, Office of Technical Services, Department of Commerce, Washington, D. C.

HARRY K. IHRIG, Director of Laboratories, Globe Steel Tubes Co., Milwaukee, was presented the Robert W. Hunt Award at the Annual Meeting of the American Institute of Mining & Metallurgical Engineers in recognition of his paper, "The Effect of Various Elements on the Hot-Workability of Steels."

EDGAR M. HASTINGS, of Richmond, Va., since 1922 Chief Engineer of the Richmond, Fredericksburg and Potomac Railroad, took office as President at the 94th Annual Meeting of the American Society of Civil Engineers recently held in New York City.

A. W. K. BILLINGS, recently retired President of the Brazilian Traction, Light & Power Co., was one of four recipients of honorary memberships presented by the American Society of Civil Engineers at its recent meeting. Mr. Billings has been an A.S.T.M. member since 1915.

PROF. R. G. HENNES, Department of Civil Engineering, University of Washington, Seattle, reports that the materials laboratory of the University of Washington has developed a quick way of curing concrete. The method was developed by Arthur Owley, a graduate student. Small cement forms were filled with concrete, submerged in water over 150 degrees in temperature and left for an hour and a half, after which they were left in a drying room for one day.

SIMON COLLIER, formerly Manager, Inspection and Control Department, Johns-Manville Corp., New York, N. Y., has been appointed Director of Quality Control. His offices will continue at 22 E. Fortieth Street, New York. Mr. Collier has been very active in A.S.T.M. work for a number of years and is chairman of Committee D-11 on Rubber and Rubber-Like Materials. He is also the 1947 Chairman of the New York Rubber Group.

C. L. EKSERGIAN, formerly Chief Engineer of the Budd Wheel Co. with his offices in Detroit, is now located at the main plant of the Budd Co. in Philadelphia as Executive Engineer.

DR. ALFRED W. GAUGER, Professor of Fuel Technology and Director of the Mineral Industries Experiment Station at The Pennsylvania State College, delivered the twenty-first annual Priestley Lecture Series at The Pennsylvania State College, State College, Penna., April 21 through 25, his subject being "Physical Chemistry and the Technology of Fuels." Dr. Gauger joined the faculty of The Pennsylvania State College in 1931 and organized the curriculum in Fuel Technology as well as the research program in the Mineral Industries. In 1942, jointly with Dr. F. C. Todd, he received the Dudley Medal from A.S.T.M. He has been an active member of A.S.T.M. since 1928, serving as member and chairman of various committees.

E. I. VALKO has been appointed Director of Research, E. F. Drew & Co., Inc., Boonton, N. J.

F. C. ZIESENHEIM is now Sales Manager, The Hydraulic Press Manufacturing Co., Mount Gilead, Ohio. He was formerly affiliated with the Lester-Phoenix, Inc., Cleveland, Ohio.

A. R. WILSON retired as of January 31 from active service as Engineer of Bridges and Buildings, Pennsylvania Railroad Co.

J. W. JONES, formerly Process Analyst, Lockheed Aircraft Corp., Burbank, Calif., is now with the Clinton Laboratories, Monsanto Chemical Co., Oak Ridge, Tenn.

S. R. SCHOLES, head of the Department of Glass Technology since 1932, has been appointed dean of the New York State College of Ceramics, Alfred, N. Y., to succeed Major E. Holmes, who died May 2, 1946. Dr. Scholes is active on A.S.T.M. Committee C-14 on Glass and Glass Products.

H. E. Hall, President, METALS DISINTEGRATING CO., Elizabeth, N. J., was reelected president of Metal Powder Association at the recent annual business meeting of the society, held concurrently with the National Metals Congress and Exposition.

L. A. LINDBERG, President, Lindberg Steel Treating Co., Chicago, has been elected president of Metal Treating Institute.

HARRY C. PLUMMER, Director of Engineering and Research, Structural Clay Products Institute, Washington, was one of a group of men interested in modular coordination who were awarded citations jointly by the American Institute of Architects, The Producers' Council, Inc., and the American Standards Association. Mr. Plummer's citation reads as follows: "For his early and continued interest in modular coordination; for his leadership of the structural clay products industry to become the first to adopt modular sizes for its products; and for the excellence of his educational program to introduce the benefits of modular products to the building industry."

ARTHUR J. TUSCANY, commissioner of the Metal Lath Association for four years, resigned his position with the organization to devote his full time to conducting the affairs of an organization designed to render trade association service to a select list of national trade associations. The Metal Lath group has named Donald R. Wadle, Pacific Coast representative for the organization since 1943 to assume the commissioner's duties with headquarters in Cleveland. Mr. Tuscany has been Chairman of A.S.T.M. Cleveland District Council for several years. His address continues to be in the Engineer's Building, Cleveland 3, but is Room 1006.

DR. SAMUEL JACOBSOHN, Gaertner Scientific Corp., Chicago, has been elected Executive Vice-President in charge of company's activities during the illness of President William Gaertner, who has been away from his desk for many months. Mr. Gaertner, now 84 years old, is one of the oldest leaders in the apparatus field.

The Steel City Testing Laboratory, Detroit, recently has changed its corporation name to Steel City Testing Machines, Inc. This company has been represented in the A.S.T.M. membership for many years, first through a membership held by H. A. Weaver, then his son, and now through the membership of JOHN GAULD, President of the company.

EDGAR HUTTON DIX, JR., Assistant Director of Research and Chief Metallurgist, Aluminum Research Laboratories, Aluminum Company of America, New Kensington, Pa., is the recipient of the 1947 Clamer Medal awarded by The Franklin Institute, Philadelphia, "in consideration of his meritorious contribution to the development of high strength corrosion-resistant aluminum products." Mr Dix is a long-time A.S.T.M. member, and is actively interested in many technical committees.

DR. LARS OLAI GRONDAHL, Director of Research and Engineering, Union Switch and Signal Co., Swissvale, Pittsburgh, Pa., has been awarded one of two George R. Henderson medals recently presented by The Franklin Institute, "for meritorious inventions or discoveries in the field of railway engineering," Dr. Grondahl being named "in consideration of his contributions over a period of years to the development which has resulted in making available a practical system of inductive train communication."

HERMAN A. HOLZ, of New York City has left for Northwestern Europe, on a special tour of investigation for the Office of Technical Services, U. S. Dept. of Commerce. Mr. Holz has been a member of A.S.T.M. since 1916.

FRANK A. RANDALL, Consulting Structural Engineer, Chicago, announces that he has taken Frank A. Randall, Jr., and John D. Randall into partnership. Mr. Randall has been affiliated with A.S.T.M. for 25 years, and is a member of the Chicago District Council.

KENNETH B. WOODS, Associate Professor of Highway Engineering at Purdue University, was recipient jointly with H. S. Sweet, also of the Purdue staff, and T. E. Shelburne of the Virginia Highway Department, of the Highway Research Board award for 1946, for their joint paper "Pavement Blowups Correlated with Sources of Coarse Aggregates."

RUSSELL J. ALLEN, Metallurgical Engineer, Worthington Pump & Machinery Corp., Harrison, N. J., is announced by The American Foundrymen's Assn., as 13th recipient of the John A. Penton medal for "meritorious service," being cited specifically "for his earnest and unceasing contributions toward the advancement of gray iron technology." Mr. Allen has been affiliated with A.S.T.M. for more than 20 years, and serves on many committees.

FELIX E. WORMSER has resigned as Secretary and Treasurer of the Lead Industries Assn. to accept an appointment as Assistant to the President of the St. Joseph Lead Co., New York. Mr. Wormser has been a member of A.S.T.M. since 1929, and is active in Committee B-2 on Non-Ferrous Metals and Alloys, and Committee B-3 on Corrosion.

NATHAN C. ROCKWOOD, Editorial Consultant, *Rock Products*, Chicago, and J. C. WITT, Technical Director, Marquette Cement Manufacturing Co., Chicago, have been elected Directors of the Chemical & Metallurgical Engineering Section of the Western Society of Engineers. Both Mr. Rockwood and Mr. Witt have been affiliated with A.S.T.M. for over 25 years and are active on several technical committees.

C. H. WELCH has been appointed Plant Manager, the Alloy Cast Steel Co., Marion, Ohio, succeeding W. A. Dorsey, recently retired. He also succeeds Mr. Dorsey as representative of the Alloy Cast Steel Co. membership in A.S.T.M.

J. D. SULLIVAN, of the Battelle Memorial Institute, Columbus, Ohio, and Chairman of A.S.T.M. Committee C-8 on Refractories, has been elected President of the American Ceramic Society.

The Drexel Institute of Technology, Philadelphia, recently made its first presentation of the "Founder's Medal of the Institute," award being made to the PENNSYLVANIA RAILROAD COMPANY "for leadership in industry." Dr. James Creese, President of the Institute, in making presentation and noting that this was the first time any such medal had been presented to a corporation by the Institute, explained that the Trustees, recognizing that Drexel is itself a product of this industrial age and a factor in the industrial prosperity of the community, have chosen to represent that fact in this medal, which from time to time will be awarded to corporations and associations contributing to the industrial, technical, economic, or social development of the Philadelphia area. The Medal was accepted for the Railroad, now completing its hundredth year of service, by President M. W. Clement.

DR. FRANK N. SPELLER has received the first Frank Newman Speller Award in Corrosion Engineering, named in his honor and presented at the Annual Conference of the National Association of Corrosion Engineers in Chicago early in April. The Willis Rodney Whitney Award in Science of Corrosion was at the same time awarded to Dr. W. R. Whitney. Dr. Speller, long-time A.S.T.M. member and officer, was honored because of his application of fundamental studies of corrosion to practical engineering problems.

HERBERT L. WHITTEMORE, well-known engineer at the National Bureau of Standards, retired recently after 29 years of continuous government service. An authority on the testing of engineering materials, he has been chief of the engineering mechanics section since 1918. His mechanical ingenuity in conducting tests of components for prefabricated houses and his study of possibilities for placing the mechanical design of small houses on a rational basis, led to development of equipment for checking accuracy of tension and compression testing machines, for which the Franklin Institute presented him with the Longstreth Medal in 1938. Mr.

Whittemore has been affiliated with A.S.T.M. since 1911, and has been an active participant in technical committee work throughout the years.

THOMAS RADFORD AGG, Dean of Engineering and Director of the Engineering Experiment Station, Iowa State College, for 14 years prior to his retirement in 1946, has returned to his first love—engineering research. In direct contrast to many engineers who divorce themselves completely from their profession upon retirement Dean Agg plans on increasing the tempo of his engineering activities. He will continue as a full-time member of the staff at the College, devoting his time almost exclusively to research in highway economics. He also plans a modernization of his book "Construction of Roads and Pavements" and the addition of a chapter on traffic engineering. Dean Agg has been an A.S.T.M. member since 1914, participating in various technical committee activities.

WILLIAM H. KLEIN, formerly Vice-President in charge of research and development with the Pennsylvania-Dixie Cement Corporation of New York, was recently appointed Assistant to the President of the Lawrence Portland Cement Company. He will continued his independent consulting practices. Mr. Klein has been an active A.S.T.M. member since 1910, and is the present Vice-Chairman of Committee C-1 on Cement.

HENRY C. BOYNTON, recently retired from John A. Roebling's Sons Co., Trenton, plans to do consulting work in the manufacture of wire and wire products. He has also done some writing for the technical press, and may continue writing.

JOSEPH S. YIKE, formerly Chief Chemist, Great Lakes Portland Cement Co., Buffalo, N. Y., is now Field Engineer, Master Builders Co., Dixie Division, Atlanta, Ga.

LLOYD A. CUMMINGS, formerly Chief Engineer of the Marlin Rockwell Corp., at Jamestown, N. Y., has been appointed Vice-President and Works Manager in charge of the Corporation's plants at both Jamestown and Plainville, Conn.

GILES E. HOPKINS is now Division Sales Manager, R. T. Vanderbilt Co., Inc , New York City.

WALTER EATON SPICER, JR., has returned to civilian life after service as Major in the Chemical Warfare Service, U. S. Army. He is now Assistant Sales Manager, Allied Home Products, Beloit, Wis.

JUDSON F. VOGDES, JR., formerly Director, Philadelphia Committee, Pennsylvania Economy League, has announced the opening of offices for the general practice of engineering in Philadelphia.

EVERETT M. PATTERSON is now affiliated with Eversharp, Inc., Long Island City, as Director of Research. He was formerly with The United States Time Corp., Waterbury, Conn., in a similar capacity.

PHILIP J. ELVING, formerly Head, Analytical Div., Publicker Industries, Inc., Research Lab., Philadelphia, is now Associate Professor of Chemistry at Purdue University, Lafayette, Ind.

C. G. SIEFERT is now President, The Tool-Die Engineering Co., Casting Div., Cleveland, Ohio. He was formerly Manager, Die Casting Div., Cleveland Hardware and Forging Co.

GEORGE W. BORTON has retired to private life after many years of service with the Pennsylvania Crusher Co., Philadelphia. Mr. Borton has been affiliated with A.S.T.M. since 1909.

HENRY NORMAN BASSETT is now Head, Technical Div., Shell Mex Argentina, Ltd., Buenos Aires. He was formerly Chief Chemist and Metallurgist with the Buenos Aires Great Southern and Buenos Aires Western Railways.

ALBERT J. PHILLIPS, Manager, Research Dept., American Smelting and Refining Co., presented the annual Institute of Metals lecture at the recent World Conference on Mineral Resources held in New York in conjunction with the 75th anniversary celebration of the American Institute of Mining & Metallurgical Engineers. His subject was "The Separation of Gases and Molten Metal."

DANIEL S. EPPELSHEIMER has been appointed Associate Professor of Metallurgical Engineering at the Missouri School of Mines and Metallurgy, where he will be in charge of instruction and research in ferrous metallurgy and the X-ray examination of metals. He was previously chief physical metallurgist and sales manager of Metal Hydrides Co., Beverly, Mass.

NECROLOGY

ROYALL D. BRADBURY, Highway Engineer, Public Roads Administration, Washington, D. C. (March 24, 1947). Member since 1930. Formerly for several years a member of Committee A-1 on Steel.

GEORGE W. HUTCHINSON, Concrete Technician, Raleigh, N. C. (March 10, 1947). Member since 1937.

J. J. ALLINSON, Vice-President, In Charge of Petroleum, Refining and Heavy Chemical Div., J. A. Jones Construction Co., Inc., Houston, Texas. Member since 1932.

J. D. TATLOCK, General Manager, Griffin & Tatlock, Ltd., London, England (November, 1946). Member since 1924.

HERBERT J. KNOPEL, Consulting Engineer, Philadelphia (August 5, 1946). Member since 1935.

ROY CROSS, President, Kansas City Testing Laboratory (March 21, 1947). Member since 1916.

Dr. Cross received his degree as Doctor of Medicine in 1908, but became interested in technical work particularly in the petroleum field. He had many patents largely in the oil industry field and had written a "Handbook of Petroleum, Asphalt, and Natural Gas." He was vitally interested in the Midwest Research Institute, and was chairman of its Board of Governors. While not active in A.S.T.M. technical work he had cooperated in connection with various A.S.T.M. activities.

F. S. DENGLER, Superintendent, Port Naches Refinery, The Texas Company, Port Naches, Texas (April 7, 1947). Member since 1922. Formerly a member of Committee D-1 on Paint, Varnish, Lacquer and Related Products 1933 to 1946.

E. B. FULKS, Consultant, American Creosoting Co., California, Mo. Member since 1925. Served on Committee D-7 on Wood for many years.

O. C. HART, Chief Chemist of Monolith Portland Cement Co., Monolith, Calif. (July 7, 1946). Represented Monolith company membership in A.S.T.M. since 1937.

BRUCE G. SHOTTON, District Manager, Hendrick Manufacturing Co., Carbondale, Pa. (April, 1947). Member since 1942.

Society Appointments

ANNOUNCEMENT is made of the following appointments:

F. M. FARMER, Electrical Testing Laboratories, Inc., as the Society's representative, and J. H. FOOTE, The Commonwealth & Southern Corp., as additional alternate, on ASA Standards Council.

J. R. TOWNSEND, Bell Telephone Laboratories, Inc., on the ASA Mechanical Standards Committee.

H. C. PLUMMER, Structural Clay Products Institute, as alternate to T. I. COE, American Institute of Architects, on ASA Section Committee A62 on Coordination of Dimensions of Building Materials and Equipment.

A. G. ASHCROFT, Alexander Smith and Sons Carpet Co., on ASA Advisory Committee on Ultimate Consumer Goods.

L. J. MARKWARDT, U. S. Forest Products Laboratory, as the Society's representative on ASA Sectional Committee O5 on Wood Poles, succeeding HERMAN VON SCHRENK, Consulting Timber Engineer, who remains on the committee as an alternate to Mr. Markwardt.

A. G. SCROGGIE, E. I. du Pont de Nemours and Co., Inc., as the Society representative on ASA Sectional Committee L14 on Fastness of Colored Textiles, succeeding A. G. Ashcroft, Alexander Smith and Sons Carpet Co.

MILES N. CLAIR, The Thompson & Lichtner Co., Inc., as the Society's representative on ASA Building Code Correlating Committee, succeeding R. P. MILLER, deceased.

G. K. LAKE, Pepperell Manufacturing Co., as the Society's representative on ASA Sectional Committee L4 on Sheets and Sheeting, succeeding R. T. FISHER, National Association of Cotton Manufacturers.

W. A. SELVIG, U. S. Bureau of Mines, as the Society's representative on ASA Sectional Committee Z23 on Specifications for Sieves for Testing Purposes, succeeding O. O. MALLEIS, deceased.

J. T. MACKENZIE, American Cast Iron Pipe Co., as the Society's delegate to the 75th Anniversary Celebration of the American Institute of Mining and Metallurgical Engineers in New York, March 17–19, 1947.

Catalogs and Literature Received

HARSHAW SCIENTIFIC (Division of the Harshaw Chemical Company), Cleveland, Ohio, Branches in Cincinnati, Ohio, Detroit, Mich., Los Angeles, Calif., and Philadelphia, Pa. This extensive new catalog of laboratory apparatus will be of interest to many of those responsible for the purchase of a wide range of laboratory supplies, scientific instruments, and related equipment. Comprising over 600 pages it is intended to cover the more common devices, and the company also states that it includes the newer instrument devices for modern techniques and procedures. The thousands of items listed are arranged in alphabetical order starting with Acid Pumps and ending with Wire Gauze. A great many of the items included are for use in connection with A.S.T.M. specifications and tests—in each case the A.S.T.M. designations are given. The illustrations are clear and have been reproduced from wood cuts. A pleasing typographic style has been followed. The descriptions of the equipment listed seem to have been carefully edited and information is presented in condensed form which, nevertheless, would cover all of the data which the purchasers of the items would normally want to have.

E. MACHLETT & SON, 220 East 23rd St., New York 10, N. Y. A four-page leaflet describing the Acme Laboratory Equipment Company's line of products, including hot air oven-sterilizer, autoclave sterilizers, electric incubators, etc. Illustrated.

CHICAGO APPARATUS CO., Chicago 22, Ill. "The Milvay Notebook," Spring, 1947. Describes the Brookfield Viscosimeter, B & L Refractometers, Thermostat-Control'ed Hot Plate, Crow Electro-Dynamic Demonstration Sets, Fully Automatic Furnaces, and New Pocket Microscope, etc. Illustrated.

THE BALDWIN LOCOMOTIVE WORKS, Eddystone Division, Philadelphia 42, Pa. Bulletin 182, "S-10 Universal Hydraulic Testing Machine." A four-page leaflet describing this testing machine and its outstanding features. Illustrated.

Also, Bulletin 251, "Southwark Plastics Molding Presses"—describes and illustrates Hy-Speed Hydraulic System, Compression Molding, features of compression molding presses, Hy-Speed Plunger Molding Presses, Steam Platen Presses, Fluid Power Pumps, Die Hobbing Presses and Custom Built Presses. 16 pages, illustrated.

STEEL CITY TESTING MACHINES, INC. (formerly Steel City Testing Laboratory), 8843 Livernois Ave., Detroit 4, Mich. A four-page leaflet, "Testing Instruments," with a number of single pages enclosed describing different types of instruments—hand-operated hydraulic Brinell Testing Machines, Universal Testing Machines, Impact Testers, Transverse Testing Machines, Ductility Testing Machines, Portable Hardness Testing Hammer, etc.

FARRAND OPTICAL CO., INC., Bronx Boulevard and East 238th St., New York 66, N. Y. Bulletin 801, describing a new instrument for research—Ultra-Violet Monochromators. Listed in this ten-page folder are six instruments: three models for spectral region, 200 to 800 mμ, with quartz-lithium fluoride optics; and three models for the visual region, 400 to 950 mμ, with glass optics. Illustrated.

LINDBERG ENGINEERING CO., 2450 W. Hubbard St., Chicago, Ill. "Lindberg Laboratory Furnaces and Equipment"—a brochure made up of glossy photographs and printed leaflets, showing various types of furnaces—box laboratory furnaces, pot crucible furnaces, indicating pyrometer controller, combustion tube laboratory furnaces, volumetric carbon determinators, etc.

News of Instrument Companies

LINDBERG ENGINEERING CO., Chicago, Ill., manufacturer of heat-treating furnaces and electrical equipment, and Fisher Furnace Co., Chicago, manufacturer of non-ferrous melting furnaces, refractories, and blowers have recently united their organizations. Under the new arrangement the Fisher organization will be known as Fisher Furnace Division, Lindberg Engineering Co. Kenneth D. Hoke, former Vice-President of Fisher Furnace Co., will head this division. Fisher furnace manufacturing and office activities have been moved to the main Lindberg office and plant at 2444 W. Hubbard St., Chicago. Refractories will continue to be manufactured at a second plant located at 5535 N. Wolcott, Chicago. The first furnace developed by the combined organization is the completely new Lindberg-Fisher induction melting furnace.

Announcement has been made by Bausch & Lomb Optical Co. of the election of I. L. Nixon and Ben A. Ramaker as vice-presidents of the company. Mr. Nixon, who has been Manager of the Instrument Division, has been with the company since 1907, becoming Instrument Sales Manager in 1932. Mr. Ramaker has been Manager of the Optical Division and has been with the company since 1902.

Calendar of Society Meetings

ILLUMINATING ENGINEERING SOCIETY—Midwestern Regional Conference, May 15–16, Kansas City, Mo.

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS—Annual Meeting, May 15–17, The Stevens Hotel, Chicago, Ill.

AMERICAN IRON AND STEEL INSTITUTE—Annual Meeting, May 21–22, New York, N. Y.

TECHNICAL SOCIETIES' COUNCIL OF NEW YORK—Annual Meeting, May 22, New York, N. Y.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS—Spring Meeting, May 23, 24, Washington, D. C.

INSTITUTE OF AERONAUTICAL SCIENCES—Light Aircraft Meeting, May 26, 27, Detroit, Mich.

ASSOCIATION OF IRON AND STEEL ENGINEERS—Annual Spring Meeting, May 25, 27, Philadelphia, Pa.

NATIONAL FIRE PROTECTION ASSOCIATION—51st Annual Meeting, May 26–29, Chicago, Ill.

METAL POWDER ASSOCIATION—Third Annual Spring Meeting, May 27, Waldorf-Astoria, New York, N. Y.

AMERICAN PETROLEUM INSTITUTE DIVISION OF REFINING—Mid-Year Meeting, June 2, 3, Jefferson Hotel, St. Louis, Mo.

EDISON ELECTRIC INSTITUTE—June 2–5, Atlantic City, N. J.

AMERICAN COKE AND CHEMICAL INSTITUTE—Annual Meeting, June 9–11, French Lick, Ind.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Summer Meeting, June 9–13, Montreal, P. Q., Canada.

American Society for Testing Materials—50th Annual Meeting, June 16–20, Chalfonte-Haddon Hall, Atlantic City, N. J.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION—55th Annual Meeting, June 18–21, Minneapolis, Minn.

AMERICAN ELECTROPLATERS' SOCIETY—Industrial Finishing Show, June 23–27, Detroit, Mich.

ASSOCIATION OF AMERICAN RAILROADS, Mechanical Division—Annual Meeting, June 23–28, Convention Hall, Atlantic City, N. J.

AMERICAN WATER WORKS ASSN.—Annual Meeting, July 21–25, San Francisco, Calif.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Bi-monthly meeting, August 26–29, San Diego, Calif.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Fall Meeting, September 1–4, Salt Lake City, Utah.

NATIONAL INSTITUTE OF GOVERNMENTAL PURCHASING—Second Annual Conference, September 15–17, Hotel Pennsylvania, New York, N. Y.

ILLUMINATING ENGINEERING SOCIETY—Annual Convention, September 15–19, New Orleans, La.

NATIONAL PETROLEUM ASSN.—45th Annual Meeting, September 17–19, Hotel Traymore, Atlantic City, N. J.

ASSOCIATION OF IRON AND STEEL ENGINEERS—Fall Meeting, September 22–25, Pittsburgh, Pa.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Middle Eastern District Meeting, September 23–25, Dayton, Ohio.

NATIONAL SAFETY CONGRESS AND EXPOSITION—October 6–10, Chicago, Ill.

NATIONAL LUBRICATING GREASE INSTITUTE—50th Annual Convention, October 16–18, Edgewater Beach Hotel, Chicago, Ill.

NATIONAL METAL CONGRESS—October 20–24, Chicago, Ill.

AMERICAN WELDING SOCIETY—Annual Meeting, October 20–24, Chicago, Ill.

PACIFIC CHEMICAL EXPOSITION—October 21–28, San Francisco, Calif.

NATIONAL ELECTRICAL MANUFACTURERS ASSN.—October 27–31, Atlantic City, N. J.

Travel directory

College Research Proceedings

THE Proceedings of the 1946 Meeting of the Engineering College Research Association have been issued and copies of the volume can be procured from Acting Secretary Miss R. A. White, University of Texas, Austin, Texas. The Proceedings include a symposium of six papers on "Factual Experiences Dealing With Overhead Charges on Sponsored Research in Colleges of Engineering and the Bases Used in Calculating Such Charges" by research directors of six engineering schools, also two other papers, "Needs for Engineering Biographies" by Dean N. W. Dougherty of the University of Tennessee and "Training of Research Engineers" by Doctor J. R. Van Pelt of Battelle Memorial Institute. A complete record of the activities of the association from 1944 to 1946 also appear in the 76-page publication. Price of the volume is $1.

Review of A.S.T.M. Research Activities

Information in Condensed Form on Large Number of Projects—Result of Detailed Studies

SEVERAL TIMES in the past we have reviewed in the pages of the BULLETIN the major research activities of our A.S.T.M. Committees. The last such complete review is that published in the December, 1943, BULLETIN. The accompanying review gives developments to date on such activities as were reported upon at that time which have been continuing, and also lists *new work* undertaken during the past four years.

The Administrative Committee on Research has recently made a canvass of research activities of all A.S.T.M. Committees. In addition, the specific problems of a number of the committees have been discussed with the committee officers. The Research Committee expects in the future to continue this practice of discussing research activities with specific committee officers with a view of coordinating research between committees and of stimulating research activities where there is apparent need for them.

As pointed out in the December, 1943, article, research on the part of A.S.T.M. Committees carries out the dual purposes of our Society in the promotion of knowledge of materials of engineering and the standardization of specifications and methods of test. Before standards for materials can be agreed upon between producers and consumers there must be agreement on methods of test. Before methods of test can be established, there is often required a great amount of cooperative research to find a method which will accurately measure the property to be determined and will give reproducible results.

It will be noted from this account of current A.S.T.M. research that a considerable part of it is devoted to this phase of research activities—the development of satisfactory test methods. Some might object to applying the designation "research" to such activities, but this work is definitely "applied" research; and it may lead to fundamental research that answers the question "why." In discussing this subject it might be in order to repeat a paragraph which was printed in the 1943 review:

"Just how to define research and how many of the projects are 'pure' or 'applied' research, and such related questions perhaps are primarily academic ones. It is interesting to realize that so many of the active projects are aiding in the solution of industrial problems. All kinds and shades of activity are represented in the projects cited. One may be the collection and correlation of existing data in certain fields and the subsequent publication of this; another may be the development of a precise method of testing involving perhaps some instrumentation problems, in which three or four laboratories of committee members cooperate in obtaining results, and then perhaps rerunning tests on a more precise basis as a check. These types and various shades of research projects stem to the very formal and extensive corrosion tests, for example, which are long-time propositions involving thousands of test specimens exposed at numerous test sites throughout the country with a large number of operators making annual inspections and listing results. Each project has its unquestioned value."

The breadth of A.S.T.M. activities and the various fields in which our committees work are certainly emphasized by the subjects covered in the review.

EDITOR'S NOTE.—The following description of research activities has, as was noted, been reviewed by the Administrative Committee on Research. In general, the same form of presentation is followed as was done in the December, 1943, review to which frequent reference is made in order to summarize past work and avoid unnecessary repetition.

In this current review the work of each committee is separately grouped, but all subjects listed in 1943 are mentioned and brought up to date along with new activities that have been undertaken. Committee reports and papers (unless the latter are indicated as separate publications) will be found in the *Proceedings* for the years indicated. Standards and methods of test will be found in the various volumes of the Book of A.S.T.M. Standards.

Ferrous and Non-Ferrous Metals

Committee A-3 on Cast Iron

Usage of Gray Iron at Elevated Temperatures.—This work was organized in 1943 in cooperation with the American Foundrymen's Association and received support from the War Metallurgy Committee. The project was completed the next year with the issuance of the specification for gray iron casting for pressure-containing parts for temperatures up to 650 F. (A.S.T.M. Designation: A 278–44 T). COMPLETED

NOTE.—At the meeting of the committee in February, a special research advisory group was appointed to facilitate investigation of new research projects, particularly in the field of stress analysis using SR strain gages.

Committee A-5 on Corrosion of Iron and Steel

Atmospheric Corrosion Tests of Copper-Bearing and Non-Copper-Bearing Uncoated Sheets.—Exposure tests began in 1915 of bare (uncoated) copper and non-copper-bearing steel and iron sheets under atmospheric conditions at three locations. The tests at Pittsburgh, Pa., were completed in 1923; those at Fort Sheridan in 1928; and those at Annapolis still continue. The 1946 committee report gives cumulative results of the tests at all three test sites. Results have shown most rapid rusting in the industrial atmosphere and especially the increased resistance due to copper additions up to at least 0.15 per cent.

Atmospheric Corrosion Tests of Uncoated and Galvanized Corrugated Sheets.—Studies began in 1926 at five test locations (Altoona, Pa., Brunot Island (Pittsburgh), Pa., Sandy Hook, N. J., State College, Pa., Key West, Fla.) representing various atmospheric conditions, on corrugated sheets both uncoated and galvanized with various weights of zinc coatings. Reference to a number of results were given in the 1943 summary. The test still continues and the latest data are given in the committee report in the 1946 *Proc.*, p. 154.

Atmospheric Corrosion Tests on Wire and Wire Products.—Extensive country-wide outdoor tests of wire and wire products, including unfabricated wire, barbed wire, wire strand, farm-field fencing, and chain-link fence started in 1936 at 11 test locations. These locations are given in the 1943 summary along with reference to a number of the earlier reports. The test is still continuing. Results after 8 yr. were reported in the 1945 *Proc.*, and the next full report is due in the committee's report of its activities this year (1947).

Weight, Uniformity, and Thickness of Galvanized and Electrodeposited Coatings.—Previous extensive studies involving tests for determining weight and uniformity of zinc coatings on hardware and other shapes and methods for plated coatings including metallographic, stripping, dropping, spot tests, etc., resulted in various tentative standards listed in the 1943 summary. A subcommittee on methods of testing is currently investigating the limits of accuracy of the various field testing methods now employed to determine the thickness of protective coatings.

Atmospheric Corrosion Tests of Metallic-Coated Hardware, Structural Shapes, Tubular Goods, etc.—As reported in the 1943 summary, studies were begun in 1928 at five test locations on metal products coated with eight types of commercial coatings. This project is continuing. A full report on progress was made in the 1944 *Proc.*, where it is noted that the tests at Altoona and Pittsburgh were involuntarily concluded due to the loss of all specimens in 1942 and 1939, respectively. Data on the results at the three remaining locations are given in the committee report in the 1946 *Proc.* Additional hardware tests are now being planned.

Committee A-6 on Magnetic Properties

Magnetic Properties—Direct Current Test Methods.—As noted in the 1943 summary, earlier work, including round-robin tests, formed the basis of standard methods of test for magnetic properties of iron and steel (A 34). Due to the press of war work, nothing has been accomplished during the past two years on the development of a d-c. permeability test method using the 25-cm. Epstein frame. This project is now being taken up once more and will undoubtedly result before long in a new tentative for consideration by the industry.

Magnetic Properties—Alternating Current Tests.—As reported in the 1943 summary, the result of early tests for alternating-current methods is also incorporated in Method A 34. The problem of developing a method, using the 25-cm. Epstein frame for measuring core losses at elevated frequencies, has been actively pursued. It was hoped to carry these frequencies to 10,000 cycles; however, the present investigation has gone only to 2000 cycles, since difficulties multiply at higher frequencies. There has resulted a tentative specification covering a test method applicable from 200 to 2000 cycles. The investigation of methods for testing at higher frequencies will be actively pursued.

Aging of Electrical Sheets.—This research project mentioned briefly in the 1943 summary is an investigation of the aging of electrical sheets at temperatures above 100 C. More important war activities prevented the progress on this project, but work is now being resumed.

Committee A-7 on Malleable Iron Castings

Malleable Iron.—No research work by Committee A-7 was reported in the 1943 review, nor is any committee-sponsored research actively under way at the present time. However, the committee has recently voted to add to its scope "the stimulation of research," and has in mind work on: (*a*) weldability of malleable castings, (*b*) malleable test bars—with particular emphasis on clarifying the use of the terms "yield point" and "yield strength," (*c*) study of combined carbon determination, (*d*) effect of sulfur in malleable iron, and (*e*) effect of chromium.

Committee A-10 on Iron-Chromium-Nickel and Related Alloys

Methods of Corrosion Testing of Stainless Steels.—Earlier work reported in the 1943 summary resulted in a tentative practice for conducting plant corrosion tests, which was revised and brought up to date in 1946 and is now designated A 224–46 T; and a method for standard boiling nitric acid test written in 1943 was revised in 1944 and is now designated A 262–44 T. A method for total immersion corrosion test of stainless steels (A 279–44 T) was written in 1944.

Atmospheric Exposure Tests of Stainless Steels.—The start of the tests outlined in the 1943 summary has been delayed, but the program is now complete and specimens will be exposed in the summer of 1947. A symposium (seven papers) on Atmospheric Weathering of Corrosion-Resistant Steels was held at June, 1946, meeting. Attached to the 1946 committee report is a special report on Passivation of Corrosion-Resistant Steels giving the concensus of the committee on this subject. There is also appended to the 1946 report, data on the performance of corrosion-resistant steel on the deckhouses of the destroyers "Farragut" and "Alwyn."

Metallographic Studies of Stainless Steels.—As reported in the 1943 summary, investigation is being made of the phenomenon of grain boundary precipitation in the 18 per cent chromium, 8 per cent nickel alloy steels with a view to determining the nature of the precipitate. A subcommittee is actively working on a new program studying the etching and identification of sigma phase and other constituents of high-chromium and high-chromium-nickel steels. There are two schools of thought regarding the sigma phase: (1) those who explain everything by it and (2) those who deny it exists. The identification of the sigma phase is admittedly difficult, but it is important in many fields such as welding. Information on the region in which it is formed is needed as well as how it can be identified.

Mechanical Tests of Stainless Steels.—As reported in 1943, previous tests produced data indicating the necessity of using in specifications the property of yield strength as determined by the offset method instead of the yield point formerly used. Appended to the 1944 report of the committee was a cooperative study of the effect of the rate of strain on tensile properties of stainless sheets. This round-robin test by five laboratories resulted in a recommendation of a limit of $\frac{1}{8}$ to $\frac{1}{2}$ in. per inch of gage length as the maximum permissible speed of testing between yield strength and fracture. Recommendation on speed to yield strength and on method of preparation of specimens, including effect of specimen shape and size, is still under study.

Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys

Atmospheric Corrosion of Non-Ferrous Metals and Alloys.—Considerable data were given in the 1943 review of the comprehensive field corrosion studies that were started by the committee in 1931, at nine test locations from coast to coast. Results of the first ten years of exposure were given in the committee report in the 1944 *Proc.* This report formed the basis of a Symposium on Atmospheric Exposure Tests on Non-Ferrous Metals, which was held at the 1946 Spring Meeting, at which authorities on different types of metal discussed the results on specific metals. This symposium has been separately published. Plans are now being laid for a cooperative exposure test with Committee B-7 on alloys of magnesium and of aluminum. A tropical location will be included in the various sites.

Total and Alternate Immersion Tests of Non-Ferrous Metals.—The initial stage of this project, reported in the 1943 review, can now be considered completed. Methods for total (B 185 – 43 T) and alternate (B 192 – 44 T) immersion corrosion tests of non-ferrous metals have been published. Cooperative laboratory testing of the methods is planned. The A-10 method for conducting plant corrosion tests (A 224) has been reviewed by Committee B-3 and mutually agreed upon changes have made this method applicable to non-ferrous metals in general. A paper on "The Effect of the Iron Content of Cupronickel on its Corrosion Resistance in Sea Water" by A. W. Tracy and R. L. Hungerford was published in the 1945 *Proc.*

Salt-Spray Test.—As recorded in the 1943 report, this work led to the issuance in 1939 of the method for salt-spray testing (B 117). In cooperation with Committee B-8, this method was reviewed and rather extensively revised in 1944 and is now designated B 117–44 T. Variations in significant factors, such as pH, air pressure, "make-up" water, etc., have been studied and the results may lead to some modifications when this tentative is made a standard. Plans are being perfected for a series of practical tests of the method on a number of representative alloys.

Galvanic and Electrolytic Corrosion.—As noted in the 1943 review, extensive earlier work on this subject is covered in a complete report in the 1939 *Proc.* Since then the tests of stainless steel coupled with various other metals which were started in 1941 have been withdrawn from exposure after five years and were exhibited at the 1946 Annual Meeting and the report on this test is now being written. In conjunction with Committee B-7 on Light Metals and Alloys, Committee B-3 is working out a test program on galvanic couples of light metals exposed to the atmosphere.

Statistical Analysis.—The practical application of statistical analysis to corrosion studies of non-ferrous metals has received considerable attention by the committee during the past few years and is being used in its new exposure tests. A paper by Messrs. Olmstead, Campbell, and Romig discusses this phase of the work and is included in the 1946 symposium referred to above.

Weather.—A study of weather factors affecting corrosion is one of the most interesting problems to which Committee B-3 is currently giving attention. This work is in the hands of a recently established subcommittee which is studying the availability and usefulness of instruments for measuring such weather factors. Considerable progress has been made and liaison has been established with other committees of the Society dealing with corrosion, so that all may benefit from the information obtained.

Humidity Corrosion Test.—Another important activity is reflected in the organization of a new subcommittee on humidity. This question of the proper method for testing the effect of high humidity and temperature is particularly active at the present time because of the interest of the armed services in equipment required to operate under world-wide and stratospheric climatic conditions. Active cooperation of the armed services in the program is assured. The work will be coordinated with that of the Technical Committee on Conditioning and Weathering of Committee E-1 on Methods of Testing and with other interested technical committees of the Society.

Committee B-4 on Electrical Heating, Resistance, and Related Alloys

Resistor Alloys in Controlled Atmospheres.—This work was started in 1939 and considerable activity was reported in the 1943 review. This resulted in developing the tentative method of test for effect of controlled atmospheres upon alloys in electric furnaces (B 183 – 43 T). This method is being further studied at the present time to determine whether it is adequate for use in evaluating the effects on high-temperature alloys of the numerous types of atmosphere encountered in controlled-atmosphere furnaces. Cast alloys are being given particular attention. The committee recently received and reviewed a report on work done by the Mond Nickel Co. in England on the causes of formation of "green rot." A study of thermocouple protection tubes and their penetration by hydrogen was laid out and will be reported on at the next meeting.

Life Test for Durability of Electric-Resistance Wire.—As reported in the 1943 review, this work resulted in the method of accelerated life tests for metallic materials for electrical heating (B 76 – 39). Since then, specifications for two of the most commonly used alloys, the 80 per cent nickel, 20 per cent chromium and the 60 per cent nickel, 16 per cent chromium, balance iron alloy (B 82 – 44 T and B 83 – 44 T, respectively), have been developed and published, which concludes the original research program.

COMPLETED

Studies of Wrought and Cast Alloys for High-Temperature Use.—As reported in the 1943 summary, this work involves the development of tests and specifications for heating and resistance alloys used at elevated temperatures. The subcommittee following this project has developed two specifications; the first for a Cr-Ni-Fe alloy (25 – 12 class) (B 190); the second, a Ni-Cr-Fe alloy (35 – 15 class) (B 207), to which requirements covering an alloy of the 38–18 Ni-Cr, balance Fe grade is being added. The committee will also consider test methods which may be useful in determining the suitability of various cast alloys for use in furnace applications. It is at present interested in the cause of cracking.

Tests for Thermostat Metals.—Cooperative research in the study of various properties of thermostat metals continues. The Committee has issued a method of test for equivalent yield stress of thermostat metals (B 191 – 44 T) and is currently engaged in the design of special equipment for use in connection with this test. The committee is also studying the effect of temperature on the modulus of elasticity and the effect of load *versus* thickness on Vickers hardness of thermostat metals.

Materials for Radio Tubes and Incandescent Lamps.—As reported in the 1943 review, the original program resulted in the publication of a number of test methods. Several new ones have since been developed, including method of test for strength of welded joints of lead wires for electronic devices and lamps (B 203 – 45 T); method of test for surface flaws in tungsten seal rod and wire (B 204 – 45 T); and method of test for diameter by weighing of fine wire used in electronic devices and lamps (B 205 – 45 T). A method of checking expansivity and transformation of glass sealing alloy is also being developed. Studies are also being carried out on the magnetic permeability of slightly magnetic materials used in lamps and electronic devices, and on particle size and density determination of powders.

Cathode Studies.—A section on cathodes has been very active, collecting data and studying the effects of composition and other variables on the emissivity of oxide-coated cathodes. Five companies have reported on tests of a series of cathode melts in diodes. Chemical and metallurgical studies are being made on the material. Experimental work is continuing, and each new melt made for the industry is being included in the test program.

Tests for Materials for Contacts.—Earlier work on this subject was reported in the 1943 review. More recently arrangements have been made for a study in seven laboratories of the following five tests of the electrical characteristics of contacts: (1) surety of making a circuit, (2) welding characteristics and weight loss, (3) arcing characteristic, (4) contact resistance build-up, and (5) life and wear. These characteristics will be determined for fine silver, tungsten, nickel, cadmium, copper, and coin silver. A paper by E. I. Shobert on "Welding or Sticking of Electrical Contacts" has been published in the 1946 B-4 compilation and a second paper will be published this year.

Committee B-5 on Copper and Copper Alloys

Tests of Copper and Copper Alloys.—Some previous work under this general heading was reported in the 1943 review. The expansion pin test (B 153—not B 95 as reported in the 1943 summary), and the mercurous nitrate test (B 154) were advanced to Standard in 1945. A hydrogen embrittlement test for copper was developed in 1944 and incorporated in a number of specifications in 1945. Current problems now being studied by the committee include the following: (*a*) the correlation of hardness scales against tensile strength; (*b*) the determination of the best type of test specimen as to preferred gage length and diameter of gage length; (*c*) methods for checking straightness of shafting and piston rod; (*d*) further data on the validity of the flattening test for tubes; (*e*) development of a better test bar for castings; (*f*) development of a test bar for centrifugal castings; (*g*) development of better methods for testing thin sheet 0.010 in. and under in thickness; (*h*) review of further data as to the limitations of the Rockwell Test for flat products; (*i*) study of impact data at subnormal temperatures; and (*j*) study of effect of speed of testing on tensile properties.

Committee B-6 on Die-Cast Metals and Alloys

Investigation of Aluminum-, Zinc-, and Magnesium-Base Die-Casting Alloys.—Considerable earlier work was reported in the 1943 review. In 1945 all of the zinc and aluminum alloy test bars exposed in 1929, and the five-year test bars of zinc and magnesium alloys (1939 series) were recalled. (Test bars of the 1939 series still continue to be exposed.) Data on these are to be found in an appendix to the 1946 committee report and additional data will be found in a paper by Gohn and Menges, both in the 1946 *Proc.* Another appendix to the 1946 report contains data on the results of ten-year atmospheric exposure tests of three aluminum die-cast alloys on which results of accelerated corrosion tests were reported in 1935 and 1936 *Proc.*

Investigation of Tin- and Lead-Base Die-Casting Alloys.—The study of 5 tin- and lead-base alloys to determine tensile strength, creep, impact, and hardness reported in the 1943 summary has now been concluded. A final report on the results is appended to the committee report in the 1946 *Proc.* p. 233.

COMPLETED

Committee B-7 on Light Metals and Alloys, Cast and Wrought

Anodic Oxidation of Aluminum and Aluminum Alloys.—As reported in the 1943 review, prior work resulted in the issuance of several test methods covering dielectric strength (B 110 – 45); the sealing of anodically coated aluminum (B 136 – 45); and a test for weight of coating (B 137 – 45). Currently the committee is investigating a test method for a new nondestructive method of testing the thickness of anodic coatings.

Minor Alloying Elements in Aluminum Casting Alloys.—Work on this project reported in the 1943 summary has been completed and the data obtained have been used by the committee in the formulation of chemical requirements in a large number of specifications.

COMPLETED

Corrosion Testing.—Committee B-7 is working in active cooperation with Committee B-3 on outdoor exposure corrosion testing of light alloys. Details have been given above in the review of Committee B-3's current activities.

Committee B-8 on Electrodeposited Metallic Coatings

Atmospheric Exposure Tests of Electrodeposited Coatings on Steel.—This research work and the two other items recorded below are an extenuation of the investigations of electrodeposited coatings reported in the 1943 review, as this work has now crystallized into several separate and distinct investigations of which this is one. The object of this research work is to determine the protective value of various thicknesses of electrodeposited lead on steel, including the

effect of a thin electrodeposited copper undercoating. For details see Committee B-8 reports in the 1944, 1945, and 1946 *Proc.*

Atmospheric Exposure Tests of Copper-Nickel-Chromium Coatings on High-Carbon Steel.—The object of this research is to determine the optimum ratio of copper, nickel and chromium in composite coatings of this type for use on automotive bumper bars. General information on these tests will be found in the reports in the 1945 and 1946 *Proc.* but no test data have yet been published.

Supplementary Coatings.—The object of this research is the evaluation of corrosion protection afforded by supplementary surface reaction finishes of the chromate type applied to zinc and cadmium. This project is in its initial stages.

NOTE.—In cooperation with the project directing subcommittees of the American Electroplater's Society Research Committees, Committee B-8 is working on the development of tests of thickness, porosity, adhesion, hardness, and ductility of electrodeposited metallic coatings.

Committee B-9 on Metal Powders and Metal Powder Products

Standard Tension Test Bars.—Better interpretation and closer correlation of investigational and control routine involving tension test bars made from sintered metal powders depends upon the development of standard test bar and a die for making it. Present indications are that two standard specimens will be needed to cover requirements adequately as the first specially designed test bar mold has given negative results due to density variations in the specimens. This work is being carried on with the advice and cooperation of Committee E-1.

Standard Electrical Conductivity Test Bars.—Closely correlated with the item reported above and with work in Committee B-4 on electrical contact materials made from metal powders is the development of a test bar which will be suitable for both tension tests and electrical resistance measurements. Cooperative tests are now being made using a bar designed with over-all length of $3\frac{1}{2}$ in. and machined to a maximum diameter of $\frac{1}{4}$ in. and a test diameter of 0.159–0.160 in. over a 2-in. gage length.

Chemical Analysis of Metal Powders.—Working closely with Committee E-3, Committee B-9 is studying the adaptability to powder analysis of existing standard methods of chemical analysis. Standard methods are also being developed for (*a*) oxide content of metal powders, (*b*) acid insoluble content of metal powders, and (*c*) iron content of iron powders. This work is also being coordinated with that of the Metal Powder Association and nine laboratories are expected to cooperate in conducting parallel tests using the methods being developed.

Sub-sieve Particle Size Determinations on Metal Powders.—The committee is working to develop sound procedures for determining particle size of metal powders by the microscopic method and the Roller air analyzer. With respect to the microscopic method, proper techniques for dispersion and mounting of the powder have not yet been completely solved and are presently receiving attention. With respect to the Roller air analyzer, parallel tests are being conducted in two laboratories on common samples preliminary to submitting a proposed method.

Compressibility of Metal Powders.—A working group has been studying a method of measuring this important property of metal powders. At present an attempt is being made to resolve the question as to whether or not it is necessary to blend powders with lubricants before making this test. Some tests indicate this to be necessary in order to get reproducibility of results while others indicate that lubrication of the punch and die alone is necessary. Twelve members of the committee have agreed to run parallel tests on samples from common lots of powders blended with lubricants, in an effort to solve this problem.

Transverse Rupture Strength of Sintered Carbides.—Work to develop a proposed standard specimen and method of test for this property is about complete and a report will be issued shortly.

Committee E-9 on Fatigue

Fatigue of Metals.—A brief summary of the more important earlier papers dealing with fatigue was given in the 1943 review. The 1944 report of the Research Committee on Fatigue of Metals presented the third progress report on the effect of size of specimen (Morkovin and Moore), and the 1945 *Proc.* contains a paper on the "Study of Size Effect and Notch Sensitivity" by H. F. Moore. At the 1946 Annual Meeting in Buffalo, there were three symposiums at which a number of papers dealing with fatigue were presented. The first of these was a Symposium on Bearings (separately published) comprising five papers; the second was a Symposium on Fatigue, eight papers presented therein being published in the 1946 *Proc.;* and the third was a Symposium on Testing of Parts and Assemblies, jointly sponsored by the A.S.T.M. and the Society for Experimental Stress Analysis. The seven papers comprising this symposium are published in a separate volume.

NOTE.—In 1946, the Research Committee on Fatigue of Metals became the Research Subcommittee of the newly organized Committee E-9 on Fatigue. At the reorganization meeting in June, a number of subjects were listed as being those to which attention should be directed at this time.

Joint A.S.T.M.-A.S.M.E. Research Committee on the Effect of Temperature on the Properties of Metals

Effect of Variables on High-Temperature Properties of Metals.—A third progress report comprising a study of effects of variables on the creep resistance of steels, by Messrs. Cross and Simmons, was appended to the committee's 1944 report. A new program is currently being prepared.

Elevated Temperature Test Methods.—A final report on the correlation of short- and long-time elevated temperature test methods was appended to the committee's report in the 1944 *Proc.* This report includes an extensive bibliography. The recommended practice for short-time elevated temperature tests of metallic materials (E 21 – 37 T) was revised and issued as standard in 1943. The recommended practice for conducting long-time high-temperature tension tests for metallic materials (E 22–41) continues as standard without change.

Stability of Steels as Affected by Temperature.—This project studying graphitization is the most active current work of the committee. It was initiated in June, 1943. In October, 1943, the committee reviewed carefully the progress of research on this subject at Battelle, sponsored by the Edison Electric Institute and the Association of Edison Illuminating Companies. A number of papers were presented at the A.S.M.E. meetings in New York City in December, 1943, 1944, 1945, and 1946. Each group has been published by A.S.M.E. under the title "Graphitization of Steel Piping." An interim report was also presented at the 1945 A.S.-M.E. Annual Meeting, and another at the A.S.T.M. Annual Meeting in June, 1946.

Gas Turbine Materials.—The committee sponsored a symposium on gas turbines at the A.S.T.M. Annual Meeting, June, 1946 (and four other papers on high-temperature applications of metals.) The gas turbine material papers have been issued as a separate publication, while the other papers are in the 1946 *Proc.* More recently, a conference has been held of those interested in the subject of gas turbine materials and a recommendation was made that a special subcommittee working under the auspices of the Joint Committee be organized to develop applicable test methods.

Cementitious, Ceramic, Concrete, and Masonry Materials

Committee C-1 on Cement

Particle Size and Specific Surface of Cement.—Development and study of apparatus and procedures for determining the subsieve gradation of particle size and the specific surface of cements, as reported in the 1943 review, is being continued. A new tentative method (C 204 – 46 T) was accepted for the determination of fineness of portland cement by the air permeability apparatus. Recently, a large number of laboratories cooperated in a study of fineness values determined by the turbidimeter and the air permeability methods. Various technical papers in *Proceedings* relate to the different methods of fineness tests.

Chemical Analysis of Cement.—Study of improved and shortened procedures, as well as new determinations, has been made. For reports of extensive cooperative studies of different methods by various laboratories, see papers in the *Proceedings* and in the BULLETIN. As a result of the more recent studies the following standard procedures have been added to C 114: Methods for determining free calcium oxide, sulfide sulfur, water-soluble alkali; rapid alternate methods for sodium oxide and potassium oxide, free calcium oxide, silicon dioxide, magnesium oxide; turbidimetric method for sulfur trioxide. New tentative methods have been submitted and approved (C 114 T) covering determinations for Vinsol resin, and Darex air-entraining agent. Current work includes cooperative investigation of methods for the determination of titanium oxide.

Determination of Strength.—Since the 1943 report, very recent work among various laboratories has included cooperative studies

of the performance of flow tables, reproducibility of flow and compressive strength tests, methods of mixing of mortars (including mechanical mixing), sizes of batches, and variations in compacting mortars in the molds. The Burmister flow trough has been developed, and modifications in the specifications for this trough have been recommended after cooperative tests were made on its use. A study of fixed water content determination is now being considered as a replacement of the flow table method.

Time of Setting.—Five laboratories have completed an extensive cooperative study of various methods, using four cements and including mortars prepared with five types of sand. The purpose is to obtain additional data to guide in planning further search for an improved test method.

Sulfate Resistance of Cement.—This work has been actively continued for some years. The subcommittee reports prepared in 1943 and 1944 appear in the 1945 *Proc.* The results of the continuation of that work covering the 1945 lean mortar tests involving the tests of ten cements by six laboratories appear in the 1946 *Proc.*, wherein also is presented a proposed method for testing, as information only, of the sulfate resistance of portland cement.

Additions to Cement.—A study of the first air-entraining addition, when interground with the cement, was completed in 1942. In 1943–1944 a second interground air-entraining agent was studied and was accepted under the tentative specification (C 175 T).

A grinding aid material was tested and accepted by C-1 under the current standard specifications for portland cement (C 150). Another material proposed as a grinding aid is now being studied by Committee C-1 to determine whether that addition is acceptable under the same specification.

Bleeding, Plasticity, and Workability of Cement.—A very comprehensive report of the working committee was presented to Committee C-1 in 1946, containing the results of investigations on the characteristics and method of operation of flow tables involving six laboratories and recommending cooperative study between this working committee and the Working Committee on Strength to standardize the 10-in. flow table and to establish the desirability of making all standard briquette mortars to a constant flow of 20 to 25 per cent.

Effect of Alkalies in Portland Cement.—Beginning in 1944, ten laboratories cooperated in the study of a proposed mortar bar expansion test. The results of that work, including measurements up to 52 weeks, have been summarized in a report that is intended for early publication.

The subcommittee that had conducted the foregoing study was just recently terminated, its work being largely taken over by a new subcommittee in Committee C-9 on Concrete, while part of the work has been transferred to the C-1 Subcommittee on Volume Change.

Sulfur Trioxide Content of Cement.—A special subcommittee was recently appointed to study the effects of variations in the sulfur trioxide content in cements. A cooperative study is now in progress covering eight cements (two each of four types) ground with seven percentages of SO_3 content to determine the optimum amount of SO_3, and from this to determine the degree of variation as it affects strength. This investigation will also cover the optimum amount of gypsum as it affects strength, expansion in water, compression in air, and the SO_3 content of aqueous mixtures. The interrelationship of the above criteria will be studied as well as the reproducibility between laboratories of the extract test and the effect of SO_3 content on concrete durability and on time of setting.

Volume Change and Soundness of Cement.—A large amount of data has been accumulated from current investigations on volume change and soundness of cements. Resulting from that study, the maximum limit for sulfur trioxide content was increased for Type I-A cement under Specifications C 175, and for Types I and III cements under Specifications C 150, in cases where the tricalcium aluminate content is greater than eight per cent. (See also Sulfur Trioxide Content of Cements.) The data also showed the effect of air-entraining agents on volume change and soundness. A joint research project has been initiated by Committees C-1 and C-9 on the Chemical Reactivity of Cement and Aggregate in Portland-Cement Concrete. The Working Committee on Volume Change, augmented by joint representation from Committee C-9, will study the problem of the development of a suitable acceptance test. The proper subcommittee in Committee C-9 (Subcommittee VI), augmented by representation from Committee C-1, will attempt to develop fundamental data.

Committee C-7 on Lime

Soundness of Lime.—Continued coordinated study is being made including the consideration of the autoclave test for measuring the relative volume change characteristics of limes.

Flow Table Standardization.—Cooperation with Committees C-1 and C-12 on the standardization of the flow table is pending.

Settling Test for Limes.—A large volume of experimental data has been submitted on the development of a method for particle-size determination by sedimentation, particularly applied to lime particles.

Action of Water in the Chemical Analysis of Lime.—At the 1947 Spring Meeting, the research problem covering the action of water in the chemical analysis of lime—as free water, adsorbed water, or water of hydration—as affected by temperature used in testing was referred to the proper subcommittee.

Committee C-8 on Refractories

Panel Spalling Test of Refractories.—Cooperative work has been carried out with the Naval Boiler Testing Laboratory in evaluating a Class C brick. An investigation of a simple and less expensive spray unit for the spalling test has been made. A critical review of the manuscript on "Recommended Practice for the Spalling Procedure" prepared by the Refractories Fellowship at Mellon Institute has been made for inclusion in Committee C-8 procedures. Revisions have resulted from this research on several standard methods of tests, namely, C 38, C 107, C 122, and C 180. Tests show that more work is needed on the phenomena of spalling.

Consistency and Plasticity of Refractories.—The research referred to in the 1943 report has been completed and two methods of test, C 179 and C 181, have been formulated. COMPLETED

Heat Transfer of Refractory Materials.—Continuation of investigation of methods for determining thermal conductivity research work at National Bureau of Standards interrupted by the war will be reestablished if possible (Report of C-8, 1946). Method C 182 has been revised but remains as a tentative (C 182 – 45 T). Two new tentative methods of test, C 201 – 45 T and C 202 – 45 T, have been formulated.

Effect of the Time Factor in the Load Test.—It is already known that refractories may be placed in a different order or merit when tested on a 24-hour schedule of heating, in place of a 2-hour schedule. The problem of creep of refractories (slow deformation under stress) is being studied in at least four laboratories, and very important work on this subject done at the Bureau of Standards during the past several years is expected to be made public in the next few months. This problem is related both to the load test and the reheat test.

NOTE.—In addition to the research projects noted above, Committee C-8 has outlined plans for study on the effect of the direction of the cut on the mechanical strength reported for a brick, problems of pyrometry as related to the measurement of the true temperature of a refractory in connection with a given test being studied, effect of atmospheric composition on the test results, spectrographic analysis applicable to the chemical analysis of refractory products, and degrees of uniformity expected in refractory raw materials.

Committee C-9 on Concrete and Concrete Aggregates

Methods and Apparatus for Testing Concrete.—Data are being collected for use in connection with a research project covering the uniformity of mixes. Continued research is necessary to establish proper methods for making the freezing and thawing test. A symposium on this subject was presented at the 1946 Annual Meeting which emphasized the need for continued activity in this respect. As a result of research study, a new method of test has been proposed by Committee C-9 for the determination of the modulus of elasticity by the sonic method. Research data are being collected for the preparation of a method of test on the strength of bond (pull-out test). The results of research on the determination of air entrained in concrete will be made available through the presentation of a symposium on this subject at the 1947 Annual Meeting. A new research project will be undertaken covering modulus of elasticity and Poisson's ratio to include actual deformation measurements so that the slope of the stress deformation diagram may be obtained at any desired load.

Study of Concrete Aggregate.—Based on research referred to in the 1943 *Proc.*, and referred to in the 1943 Summary, broad changes have been recommended in A.S.T.M. Standard C 87 on Structural Strength of Fine Aggregate. COMPLETED

Admixtures for Concrete.—A new subcommittee is investigating admixtures for concrete used only as additives to the batch. Research data have been collected for a proposed method of test of the evaluation of admixtures in concrete. This method will be published in the ASTM BULLETIN as information only, pending the accumulation of further experience data.

Chemical Reactions of Aggregate in Concrete.—Joint activity has been inaugurated by Committees C-1 and C-9 on the chemical reactivity of cement and aggregate in concrete. (See Volume Change and Soundness of Cement under Committee C-1.) The proper subcommittee of Committee C-9 augmented by representation from Committee C-1 will study the problem from a fundamental research viewpoint. The problem will be to decide what the reactions are and how to con-

trol them so that only the desirable reactions will take place. A very comprehensive bibliography covering the subject of disintegration of concrete has been prepared by the Joint Research Project at Purdue University and revised by Subcommittee VI.

Committee C-12 on Mortars for Unit Masonry

Testing Mortars for Unit Masonry.—Investigations of the elastic and plastic properties of mortar in masonry assemblages were two thirds complete, and a study of mortar workability under constant stress was one third complete when the war drafted assisting personnel. It is planned to resume these investigations as soon as laboratory space and additional help become available.

Methods of Analysis of Masonry Mortars Taken from the Mortar Board.—Attention is being given to developing methods to determine whether adequate portland cement has been added to a mixture of lime putty and sand delivered on the job, and to determine whether masonry mortar taken from the board has adequate workability and will probably provide a suitable durability.

Methods of Testing Various Waterproofing Materials.—A study is being made of those methods proposed for preventing masonry mortar joints from leaking.

Committee C-14 on Glass and Glass Products

Chemical Durability of Glass and Glass Containers.—At the present time subcommittees III and VIIA are working together on a comparative study of ten methods (four U. S. Pharmacopeia and six from Subcommittee III) on the Chemical Durability of Glass and Glass Containers for the purpose of reducing the number of tests methods to a minimum and to permit selection of a reasonable number of standard tests.

Examination and Testing of Glass Containers.—Three standards set up in 1943 are now being revised as a result of experience and knowledge gained through use over the past five years and from work in progress in several individual laboratories. These are (1) Standard Method of Hydrostatic Pressure Test on Glass Containers (C 147 – 43), (2) Standard Method of Polariscopic Examination of Glass Containers (C 148 – 43), and (3) Standard Method of Thermal Shock Test on Glass Containers (C 149 – 43).

Progress on the ring section examination method of glass containers is expected to be held up for at least two years due to lack of availability of suitable optical equipment. A suitable sampling method for glass containers based on the experience of the Army Ordnance Department is in process of formulation.

Physical and Mechanical Properties of Glass.—A round-robin testing program involving several laboratories resulted in the comparison of a number of tests methods tried out on glass rods of many compositions. The result has been the writing of a Standard Method of Flexure Testing of Glass, C 158 – 43. The method is applicable to round rods as well as to strips cut from flat glass.

Glass Construction Block and Tile.—Test data are being accumulated on methods for sampling and testing structural non-load-bearing cellular glass blocks. A similar study is anticipated on methods applying to structural glass blocks.

Committee C-15 on Manufactured Masonry Units

Performance Data on Clay Masonry Products.—Performance data on clay masonry products accumulated by the committee will be supplemented by a research program of the Structural Clay Products Institute on masonry units and walls which was started at various universities and at the Bureau of Standards and interrupted during the war is now being revived.

Committee C-16 on Thermal Insulating Materials

Physical Properties of Thermal Insulating Materials.—Research in general continues, with special attention being given to methods of test covering loose fill insulating materials. A number of A.S.T.M. standards and tentatives have been published resulting from previous study, namely: Method of Test for Bulk Density of Thermal Insulating Cement (C 164 – 44); Method of Test for Compressive Strength of Preformed Block Type Thermal Insulation (C 165 – 45); Methods of Test for Covering Capacity and Volume Change Upon Drying of Thermal Insulating Cement (C 166 – 45); Methods of Test for Thickness and Density of Blanket Type Thermal Insulating Materials (C 167 – 44); Specifications for Structural Insulating Board Made From Vegetable Fibers (C 208 – 46 T); and Methods of Testing Structural Insulating Board Made From Vegetable Fibers (C 209 – 46 T).

Conductivity of Thermal Insulating Materials.—Further check tests are being run on the Van Rinsum type conductimeter and the present type of apparatus at the Johns-Manville Laboratory and the Mellon Institute on the same samples of pipe insulation. Method of Test for Thermal Conductivity of Materials by Means of the Guarded Hot Plate (C 177) was revised in 1945.

Vapor Barrier Study.—Eight items are proposed for fundamental research projects. The first endeavors will be the collection of literature on existing work, the evaluation of certain terms and applications and the formulation of tests. These items are: (1) velocity of diffiusion; (2) permeability as a function of the moisture content of material; (3) the effects of holes in vapor barriers; (4) isolation of the effects of diffusion, hygroscopicity, infiltration, and solution; (5) film resistance at the face of solids; (6) sublimation rate of water; (7) evaporation rate of water; and (8) migration of water through soils.

Committee C-18 on Natural Building Stones

Exposure Test on Stone Masonry.—The objectives are to obtain information on the durability and color permanence by actual exposure to the weather. Thirty-three types of stone with 2000 samples represent deposits in 45 states and several foreign countries. The test wall is to be divided into two parts, one of which will be set with lime mortar and the other with portland-cement mortar for comparison. Other questions under consideration are the effects of combining limestones and sandstones and of combining limestones and dolomites. This is a joint research between the A.S.T.M. and the National Bureau of Standards, and the test wall is to be built on the grounds of the latter institution.

Paint, Petroleum, Gaseous Fuels, Coal, Roofing Materials

Committee D-1 on Paint, Varnish, Lacquer, and Related Products

Accelerated Tests for Protective Coatings.—This project includes a study of accelerated weathering tests for such protective coatings as house paints, enamels, varnishes, lacquers, and metal protective finishes; also correlation of the results with outdoor exposure tests. For information from extensive questionnaire on accelerated test for paint coatings see December, 1940, BULLETIN. Since 1941, pictorial reference standards have been established for rusting (D 610), blistering (D 714), chalking (D 659), checking (D 660), cracking (D 661), erosion (D 662), and flaking (D 772). Projects just completed include recommended practice for operating exposure apparatus (D 822) and immersion test (D 870). The following problems are being studied: (1) preparation of steel panels, (2) humidity testing, and (3) light and water exposure apparatus.

Synthetic Solvents.—Under a newly organized subcommittee extensive work is planned including study of solvency, the compatibility of solvents in various mixtures; also methods of analysis of mixtures of various classes of hydrocarbons used as solvents and thinners. These studies are to be carried on in cooperation with the appropriate subcommittees of Committee D-2 on Petroleum Products and Lubricants but the D-1 study will be particularly on the grades of material used in paints and their application to paint. Another project will cover methods for measuring evaporation rates of solvents.

Consistency of Paint Including Enamel Type Paints and Lacquers.—Based on cooperative investigations of certain instruments, including the Stormer viscosimeter, A.S.T.M. consistency cup, Ford cup, etc., standard methods have been completed for testing nitrocellulose clear lacquers and lacquer enamels (D 333), for consistency of exterior house paints (D 562) latter uses the Stormer viscosimeter with paddle-type rotor. A new viscosimeter method is described in the 1947 Symposium on Paint and Paint Materials.

Preparation and Paint of Structural Iron and Steel.—Work is under way investigating different methods of surface preparation of steel for painting. Detailed 1941 Report describes research work and summary of various investigations and inspections of panels on exposure; lists reports which cover earlier tests at Havre de Grace and Atlantic City; gives observations of committee in charge. While tests are continuing, the latest plan of the committee involves further series to determine the effect of chemical pretreatment on steel which has been previously painted and then exposed until rusting occurs. Consideration is being given to

standardizing procedure for field testing of paints on steel; also to test sites for exposure tests of paints on steel.

Physical Properties of Paint.—The scope of this project covers various physical properties of paint, but particular emphasis has been placed on investigation of "gloss." Current studies include preparation of films for measurement of gloss. Investigations are being conducted on infrared reflectance and flame testing; also numerical expression of color differences; and adhesion of protective coatings. New tentative method for measurement of film thickness (D 823) has just been issued. Studies of abrasion resistance of coatings are reported in two papers published in ASTM BULLETIN, December, 1946, "The Falling Sand Abrasion Tester" by C. C. Hipkins and R. J. Phair, and "A New Sandpaper Abrasion Tester" by F. M. Gavan, S. W. Eby, Jr., and C. C. Schrader.

Properties and Tests of Varnishes.—Studies of the physical and chemical properties of varnishes are involved. Current cooperative tests are being made on methods of measuring dust-free time, set-to-touch time, tack-free time, and thorough drying. Studies of tests for alkyd resin solutions are under way.

Tests for Traffic Paints.—Rapidly increasing use of traffic paints intensified necessity of adequate standard tests. In its studies the committee has accumulated considerable data on laboratory tests as compared with road durability tests. Following tests have been established for traffic paint: dry to no-pick-up time (D 711), light sensitivity (D 712), road service tests (D 713), abrasion and erosion (D 821), bleeding (D 868), and settling (D 869). Current problems include the establishment of photographic standards for traffic paint failures, measurement of hiding power and of day and night visibility, method of evaluating degree of resistance of traffic paints to chipping (procedure applicable to both laboratory and road service tests, including a set of photographic standards), accelerated laboratory durability tests, and accelerated settling tests based on alternate heating and cooling of paints.

Drying Oils.—Studies are being made of tests for acetone number and heat bodying.

Optical Properties.—The following eight projects are under consideration: (1) methods of color specification, (2) goniophotometry, (3) preparation of panels for gloss determination, (4) color difference measurements, (5) daylight reflectance, (6) preparation of panels for apparent luminous reflectance of traffic paints, (7) determination of gloss, and (8) tests for absolute hiding power.

Committee D-2 on Petroleum Products and Lubricants

Kinematic and Saybolt Viscosity.—Resulting from investigations involving particularly kinematic viscosity were methods of test using the suspended level and modified Ostwald instruments, and a method for conversion of kinematic viscosity to Saybolt Universal and Furol viscosity (D 445, D 446, and D 666). Due to increased use of additives of various types and the introduction of synthetic oils, work is being undertaken on methods of test for viscosity at various rates of shear.

Neutralization Number and Saponification Number.—Two tests for neutralization number have been developed, one by color-indicator titration (D 663), another by electrometric titration (D 664); and one for saponification number by color-indicator titration (D 94). Cooperative work in nine laboratories on tests for electrometric saponification number are now under way. A large number of colorimetric methods are also being investigated. A set of samples is being distributed for testing various methods.

Lubricating Grease.—Studies include (1) chemical and general laboratory tests for lubricating grease, (2) consistency measurements and related physical tests, and (3) functional tests for lubricating grease employing anti-friction bearings. Two new tentative methods to be issued this year cover stability test by oxygen bomb, and cone penetration tests. Two proposed methods to be published as information cover test for evaporation characteristics and dropping point tests. Results of current investigations on rapid methods of grease analysis, a cooperative study of the thixotropy of greases, and on determining consistency of small samples of lubricating grease will be published in ASTM BULLETIN.

Tests of Gasoline.—This research program includes active cooperative studies of tests for tetraethyl lead in gasoline, detonation, sulfur, and volatility. Several new and revised methods are to be issued this year.

Pour Point Test of Petroleum Products.—As a result of a number of years experience, it has been found that lubricating oils containing pour point depressants, either natural or synthetic, solidify under certain atmospheric temperature cycles at temperatures not predicted by A.S.T.M. Method D 97. This led to a study and report on the effect of temperature cycles on the temperature at which oils solidify (*Proc.* 1945, p. 237) and to the publication as information of a Proposed Method of Test for Maximum Pour Points of Lubricating Oils Containing Pour Point Depressants (*Proc.* 1945, p. 244). Actual storage tests conducted during the winter 1944–1945 on a large number of oils under atmospheric conditions at a number of geographic locations showed the proposed method to correlate better with practical storage than Method D 97 (BULLETIN Jan., 1946, p. 44), but still left much to be desired. Field tests were continued during the winter 1945–1946 and results were no better. Parallel work on the more fundamental aspects of this problem including work on solid-liquid phase behavior in hydrocarbon systems is continuing in several laboratories of subcommittee members in order to determine what factors, physical and chemical, control the solidification of such systems.

Color of Petroleum Products.—Extensive studies are under way of A.S.T.M. Union (D 155) and Saybolt (D 156) color methods on standard solutions and oils in order that a correlation curve can be developed; also a color index scale. Studies made of photoelectric colorimeter for determining color of lubricating oil has resulted in a proposed method to be published as information this year.

Turbine Oils.—Studies concern factors which influence life of turbine oil, rusting behavior, oxidation stability on oil systems of turbines, emulsion tests, and load-carrying capacity tests. Based on rather extensive interlaboratory tests of four turbine oils, a proposed test for oxidation characteristics was published as information in 1943 Report (*Proc.* 1943, p. 275). This report also gives field service data on turbine oils. Methods for rusting (D 665) and foaming characteristics (D 892) have been issued as tentative.

Aniline Point.—Current cooperative test program covers study of the "Sil-U-tube" in place of the present test tube in Method D 611 to cover light-colored oils and those as dark as can be measured with cell type apparatus.

Petroleum Sulfonates.—Considerable cooperative research work is under way involving study of methods for determining sulfonate content; oil content of sulfonate samples; water, moisture and volatile matter, inorganic salts, etc. Petroleum Sulfonates Method D 855 was issued in 1945. Current studies are under way on analysis of calcium and barium petroleum sulfonates; also on a new method for inorganic salts.

Inorganic Elements in Lubricants.—Several methods have been completed (for sulfur, D 129; for chlorine, D 808; for phosphorus, D 809; for lead, copper, and iron, D 810; and for metals, D 811). Other methods being studied include tests for sulfated residue from lubricating oils, sulfur in lubricating oils and in additive concentrates by bomb method, and for phosphorus in organic materials (acid oxidation method).

Analysis of Petroleum Products for Hydrocarbon Types.—Projects under way include (1) tests for olefins and aromatics in petroleum distillates (method issued this year provides procedure needed in Federal Specification AN-F-34 and for jet propulsion fuels), (2) determination of total olefin plus aromatics by acid testing, (3) determination of olefinic unsaturation by chemical means, (4) analysis of hydrocarbons by adsorption (proposed method published in *Proc.* 1946, p. 356), (5) refractive index, dispersion and density, (6) purity by freezing point (to be issued as tentative in 1947), and (7) spectroscopic methods for analysis of hydrocarbons. Procedure for determining benzene and toluene by ultraviolet light method is to be issued as tentative in 1947. Other methods being studied include ultraviolet method for butadiene and infrared method.

Lubricating Oils.—Studies are under way on oxidation and bearing corrosion, foaming (new tentative Method D 892 issued this year), laboratory testing of instrument oils (see BULLETIN paper entitled "The Comprehensive Laboratory Testing of Instrument Lubricants," March, 1946, p. 25, also *Proc.* 1946, p. 1540). A Symposium on Synthetic Lubricants will be held at 1947 Annual Meeting.

Light Hydrocarbons.—New technical committee will consider screening tests, general testing methods, chemicals including pure hydrocarbons, tests for natural gasoline, and for liquid petroleum gases.

Committee D-3 on Gaseous Fuels

NOTE.—Through active participation of their representatives, the committee has been able to instigate and use research work carried out at the National Bureau of Standards, Pennsylvania State College, and other laboratories.

Measurement of Gaseous Samples.—Work was carried out at the National Bureau of Standards to develop procedure for testing laboratory wet gas meters. Papers by Bean and Morey, and Jilk, covered experimental work (*Proc.* 1939, p. 1171 and p. 1159). Based on this investigative work, the committee has prepared a proposed method of measurement of gaseous samples using wet gas meter which is now being studied.

Specific Gravity and Density.—In this extensive work carried out at the National Bureau of Standards, 15 test gases were employed with more than 2000 specific gravity determinations made, using eleven instruments submitted by various manufacturers. An extensive report of some 240 pages was

prepared and distributed to the members of the supervising committee and members of Committee D-3. Investigative work is completed and results are to be published by National Bureau of Standards. A study is being made of tolerances for specific gravity measurements and, when completed, a proposed method will be prepared.

Water Vapor Content of Gaseous Fuels.—Intensive work was carried out at Pensylvania State College on two methods for the measurement of moisture in fuel gases, namely, a laboratory method which depends on the absorption of light by the water vapor at a particular wave length in the near infrared, and a field method which depends on the change of color of cobaltous bromide in an organic solvent on the addition of water. See 1942 Dudley Medal paper by F. C. Todd and A. W. Gauger, "Studies on the Measurement of Water Vapor in Gases" (*Proc.* 1941, p. 1134). Studies are now under way of the aero water vapor detector in comparison with other methods.

Complete Analysis of Gaseous Fuels.—Results of studies on two standard samples of gas analyzed in 24 laboratories are published in National Bureau of Standards *Journal of Research* (*RP1704*), March, 1946. These data give first reliable information of the precision and duplicability of results from this type of gas analysis. Two other standard samples are now being analyzed: one by the mass spectrometer (75 per cent completed), the other a natural gas sample being tested by 10 laboratories. The committee expects to have the answer during the coming year as to which of the three methods will give the best reproducible results.

Determination of Special Constituents of Gaseous Fuels.—An investigation is now in progress at the Institute of Gas Technology, Chicago, Ill., on the identity and proportions of specific sulfur compounds in gaseous fuels. One investigator is devoting his full time to the preparation of analytical methods covering determination of total organic sulfur, carbon disulfide, carbon oxysulfide, mercaptans, and thiopenes.

Determination of Calorific Value.—Method D 900 completed this year is an extensive method for calorific value for gaseous fuels by the water-flow colorimeter. This method gives in detail requirements for apparatus, test procedure, theory, and calculations for this test, which is of fundamental importance in evaluating gaseous fuels.

Committee D-4 on Road and Paving Materials

Extraction and Recovery of Bitumen from Asphaltic Materials.—Method D 762 – 44 T was prepared based on a modified Abson procedure. A summary of data on which this method is based was included in the 1944 Report of Committee D-4 (*Proc.*, Vol. 44, p. 401). COMPLETED

Sulfonation Index of Road Tars.—Method D 872 – 46 T is based on extended cooperative work under the auspices of the A.A.S.H.O. by a subcommittee whose membership comprises several members of A.S.T.M. Committee D-4. The object of this work was to develop a more accurate and reliable method for use with road tars. COMPLETED

Residue by Evaporation.—Subcommittee B-17 has prepared a proposed method of test for residue by evaporation, which is now recommended for incorporation in A.S.T.M. Method D 244 – 42. Cooperative work was conducted by four laboratories, and the data presented included results showing the percentages of residue obtained both by evaporation and distillation of six or more samples of asphaltic emulsion. Comparative data on penetration and ductility of these residues are also shown in the report presented to the committee. COMPLETED

Soil Bituminous Mixtures.—A report of research was presented to the Joint Subcommittee of Committees D-4 and D-18 at the Annual Meeting in 1946 (see 1946 *Proc.*) resulting in methods of test which will be presented at the 1947 Annual Meeting. Research projects are in progress on: (1) compaction, density and moisture in soils; (2) permeability of granular stabilized soils mixtures; (3) a method of test to determine the strength of granular stabilized mixtures; and (4) a study of the moisture-proofing ability of various admixtures.

Committee D-5 on Coal and Coke

Ignitibility of Coal and Coke.—Experimental work on laboratory test for ignitibility of coal is described in Oct., 1941, ASTM BULLETIN, p. 23. This research has shown that method under consideration is not entirely satisfactory and more research work needs to be done. The current problem is to determine whether the values obtained can be correlated with actual burning characteristics.

Plasticity and Swelling of Coal.—Studies are being made of methods of testing expanding properties of coals during coke manufacture. Investigation of plastic properties of coals as affecting their combustion characteristics are also being conducted. The test for free-swelling index of coal (D 720) and the proposed methods for determining plastic properties of coals mentioned in the 1943 Review are published in the 1947 Committee D-5 Compilation. Much experimental work on various methods for testing plastic and expanding properties of coals has been conducted since 1943 by laboratories of the U. S. Bureau of Mines and by the Research Division of the Koppers Co. Work done by the Bureau of Mines and published in 1943 and later is described in Bureau of Mines *Technical Papers* 650, 655, 667, 970, 672, and and 683, in Report of Investigations 3760. A comprehensive critical review of published information on test methods for measuring the "plastic" and "swelling" properties of bituminous coking coals is given in Bureau of Mines *Bulletin 445*, "Plastic and Swelling Properties of Bituminous Coking Coals," by R. E. Brewer.

Sampling and Tolerances for Coal.—Earlier sampling experiments involving hand and machine methods and various coals with different amounts of impurities resulted in standard methods of sampling coals (D 492). A mathematical study of the principles governing the establishment of specifications for the sampling of coal was published by the U. S. Bureau of Mines as *Bulletin 454*, "Fundamentals of Coal Sampling," by B. A. Landry. Another statistical study of coal sampling was published in *Transactions* of the A.S.M.E. for February, 1945, in the paper, "The Missing Data on Coal Sampling," by B. A. Landry. Latest problem being studied involves sampling coal for the determination of volatile matter in connection with city smoke ordinances.

Coal Ash Fusion Test.—To obtain information on how best to specify the nature of the reducing atmosphere in the standard coal-ash fusion test a cooperative investigation has been completed. Gas-fired and electrically heated furnaces were used. The fuels in the gas-fired furnaces included natural gas, manufactured gas, coke-oven gas, and oxygen-acetylene mixtures. The 17 cooperating laboratories determined in duplicate the initial deformation temperature, the softening temperature, and the fluid temperature of a series of coal ashes covering a wide range of fusibility. This investigation is described in U. S. Bureau of Mines Report as R. I. 3724, "Cooperative Investigation of the Effect of Furnace Type and Atmosphere on the Fusibility of Coal Ash," by H. M. Cooper and R. F. Abernethy. A paper, "The Flow Characteristics of Coal-Ash Slags in the Solidification Range," by W. T. Reid and P. Cohen, covering research done by the U. S. Bureau of Mines, was presented at 1943 annual meeting of A.S.M.E. and published by A.S.M.E. in May, 1944, in a collection of reprints of various papers entitled "Furnace Performance Factors." COMPLETED

Sampling and Fineness of Powdered Coal.—Plans are being made to investigate methods of sampling and fineness tests for powdered coal, with a view of revising Standard D 197 – 30. The new Subcommittee XX on this subject is now investigating dry and wet sieving methods as well as air-permeability methods for specific surface determinations.

NOTE.—Two other projects listed in the 1943 review have been completed. These are (1) determining sulfur in coal and coke, and (2) uniformity of analytical data.

Committee D-7 on Wood

Moisture Content of Timber.—Since the 1943 report, research has been continued in the field of application of instruments for determining the moisture content of wood and in the development of new or improved methods applicable to the determination of moisture content. In the meantime, further research and study has been carried on with the thought of eventually developing the necessary information and data as a basis for preparing specifications for the determination of moisture content by electrical methods.

During 1946 consideration was also given to the development of methods especially applicable to the determination of the moisture content of treated wood. For this type of material the usual oven-dry method is not accurate, and moisture meters do not give reliable results. A new method has been developed based on the dewpoint principle. A paper presenting a description of the apparatus is to be published in the BULLETIN in the near future.

Laminated Timber.—A large volume of research work on laminated construction is under way by agencies coordinating with Committee D-7. The need has been stressed for standard tests to cover laminated material for different kinds of service—both inside and outside.

Study of the Effect of Specimen Shape on the Compressive Strength Properties of Laterally Supported Plywood Specimens.—The purpose of this research was to compare results obtained with prism-shaped specimens such as those commonly used for compression tests on wood and plywood with hour-glass shaped specimens of two different types. Also included in the study was a series of tests to determine the effect of end condition on tests results. The results were presented in an article by J. A. Liska in the March, 1945, ASTM BULLETIN. The results of the study have been used as a basis for setting up the proper procedure in A.S.T.M. Tentative D 805 – 45 T. COMPLETED

Effect of Specimen Shape on the Tensile Strength of Plywood and Veneer.—The purpose of this research is to compare the results obtained with several types of test

specimens, including specimens of reduced cross-section with various fillets, as a basis for determining the most efficient form and size of specimen, the maximum possible economy of material, and the comparison of results with specimens employed for tests of plastics. The results of these studies should lead to the adoption of recommended standards for alternate test specimen types.

Committee D-8 on Bituminous Waterproofing and Roofing Materials

Stain Properties of Bituminous Materials.—Subcommittee XIII on Tests for Stain Properties of Bituminous Materials has been formed and is actively at work. The committee is trying to develop a method or methods for measuring accurately the extent to which bituminous materials exude an oily constituent under conditions of use which result in the staining, for example, of laminated paper, prepared roofing, and floor coverings.

Electrical Insulating Materials, Shipping Containers, Rubber Products, Soaps, Textiles, Adhesives

Committee D-9 on Electrical Insulating Materials

Power Factor and Dielectric Constant of Electrical Insulating Materials.—There are five sections actively working on the following projects: (1) tests for resistivity and insulation resistance involving a study of long-time changing current curves; (2) measurement of power factor of liquids and power factor tests after immersion, (3) power factor of solid insulating materials at frequencies up to hundreds of megacycles per second (with removal of restriction in the field of "ultra high frequencies" this section will have a big program); (4) testing various types of electrode materials and other methods of application; and (5) study of arc-resistance tests involving round robin tests based on current techniques and procedures.

Solid Treating and Filling Compounds for Electrical Insulation.—Considerable work has been done on test methods for waxes. When completed, these test procedures are to be included in Method D 176 mentioned in the 1943 review. Studies are also under way on oil solubility of solid filling and treating compounds. A report on this has been circulated to the subcommittee.

Varnished Cloth Tapes (Insulating Fabrics).—Problems being studied since those listed in 1943 include: (1) revising the present elongation-dielectric strength requirements to approximate more closely conditions of service; (2) possible substitution of standard humidity requirements for conditioning in place of the present 60 to 65 per cent; (3) further study of an alternative power factor test method which will eliminate vacuum treatment; (4) revision of the sampling procedure to make the number of rolls to be tested more nearly proportional to the yardage purchased; and (5) stiffening the rejection requirements in the specifications. Progress has been made during the past year in the investigation of the slow-rate-of-rise dielectric strength test intended to replace the present step-by-step test for varnished cloth. Considerable test data have been accumulated, and the proposed method has met with favor in a number of laboratories. Simple modification of the present motor-driven voltage control has been evolved to include in this test. New section on electrical adhesive tapes has been making extensive investigations of a number of pertinent properties including thickness, adhesivity, effect of heat and moisture, tear resistance, tensile strength, fungus resistance, metal corrosion, electrolytic corrosion, and effect of varnishes, solvents, and oils.

Tests of Electrical Insulating Papers.—A new method for pH value (hydrogen ion concentration) of paper prepared by a joint D-6–D-9 committee was completed in 1946 and included in Methods D 202. Study of water extract conductivity test and a new air-resistance method are being undertaken. New test work being undertaken on a pH method for vulcanized fiber, and chlorine methods for phenol fiber and insulating papers.

Tests of Electrical Sheets, Tubes, and Rods.—Problems being investigated include: (1) effect of specimen size and conditioning procedures on measurement of insulation resistance and on the effect of high and low temperatures on power factor of sheet insulating materials; (2) electrical properties of various thermoplastic molded materials and sheets; and (3) tests for bending strength of laminated materials and vulcanized fiber. A flexure test of plastics (D 790) was completed in 1944. Also a revised tension test for sheets, tubes, and rods (D 638) was completed in 1945. This latter item was the result of cooperation among D-9, D-20, and The Federal Specification Board committees.

Tests of Electrical Insulating Varnishes.—Four groups are actively at work on the following projects: (1) deep-drying properties of varnishes used for impregnating properties; (2) heat endurance test; (3) resistance to acid and alkali and sea water; and (4) study of various cup designs in determining "set time" of thermosetting varnishes. The Section on Deep-Drying Varnishes is actively engaged in developing a test method for determining the deep-drying properties of varnishes used for impregnating purposes. This program of work is a continuation of work which has been in progress for about 14 years. To set up a test method which will select an appropriate varnish for this use is most difficult because the conditions prevailing in actual use are difficult to simulate in a test method. However, during the past year's work a great deal of information has been accumulated and with this experience as a background, the cooperating laboratories expect that a satisfactory test method or methods may soon be developed by round robin tests.

Tests of Electrical Liquid Insulation.—This project includes studies of a number of problems in the evaluation of electrical insulating oils as described below:

Sludge Test.—Correlation tests being continued in 20 cooperating laboratories to determine relation of sludge test values by Method D 670 with actual service life of insulating oil in transformers. Studies include tests on a bank of 12 transformers and will require approximately five years of operation in order to obtain sufficient data on which to base conclusions. As a result of this work, it is hoped to determine whether Method D 670 will actually differentiate between good and bad oils and correlate with actual service life obtained with these oils in transformers.

Water in Insulating Oil.—Round robin tests are under way on methods to determine minute traces of water or moisture in insulating oils. Studies include Karl Fischer method and Doble methods. The latter is described in paper "Water Determination in New and Used Insulating Oils by Dobl.-Method," by F. C. Doble (*Proc.* 1946, pe 1475).

Insulating Oils and Askarels.—Results of questionnaire on tests of transformer oils in service obtained from 67 utility companies were published in 1945 *Proc.*, p. 302. The report includes extensive tabulation and analysis of the data and information received. Methods of testing askarels (D 901) were issued as tentative in 1946. Studies are also being made of method of determining corrosive sulfur in insulating oils, and an interfacial tension test. A Symposium on Insulating Oils held at October, 1946, Meeting of Committee D-9 included papers on interfacial tension tests, and on steam-emulsion number. (See BULLETIN, May and August, 1947.) A further symposium to be held at the June meeting will cover inhibitors of electrical insulating oils, and also power factor tests.

Dielectric Strength, Resistivity, and Power Factor Tests.—Studies of these tests are continuing. Further studies of dielectric strength test cover relative merits of one sheet *versus* five sheets per filling, dielectric strength tests of heavy insulating oils, and of askarels. New test for dielectric strength (D 877) issued in 1946.

Tests for Properties of Ceramic Products for Electrical Purposes.—This project, recently organized, now comprises studies of (1) porcelain stone ware and vitreous products; (2) glass and glass insulators; (3) steatite and related low-loss ceramics; and (4) glass bonded mica. On item 3 data are being tabulated and analyzed on the loss factor test of steatite. Additional round robin tests are under consideration. Studies of test methods for glass bonded mica are expected to be initiated shortly.

Mica and Mica Products.—Based on an electrical system of classifying mica, tentative specifications and tests for natural block mica (D 748) have been completed. The new electrical "*Q*" value test is considered to have many advantages over the visual system. The extensive groundwork connected with this development was instituted and carried to completion by the Bell Telephone Laboratories. The work has indicated that certain classes of mica heretofore thought unsuited for certain particular electrical application can be used quite satisfactorily. Arrangements have been made to secure a trial lot of three mica samples reproduced photographically in color. If the trial lot proves satisfactory, an entire set of mica selected to show various grades or classifications as prescribed in Method D 351 will be reproduced and made available upon order. It is felt that such a series of photographs may prove to be of material value to those using the visual system of classifying mica.

A very comprehensive round robin study of the "*Q*" test on block mica has been completed. Seven laboratories participated.

The purpose was three-fold: (1) to determine the degree of agreement among various laboratories using the rapid method, (2) to determine whether circular lead foil electrodes 2 in. in diameter, affixed with petrolatum were satisfactory for measuring the "*Q*," and (3) dielectric constant of block mica approximately 0.020 in. in thickness at 1 megacycle. The results of this round robin test are presented in a paper by K. G. Coutlee on "Electrical Quality Classification of Raw Mica by a Rapid Reading Method" (1946 *Proc.*, p. 1486).

Committee D-10 on Shipping Containers

Vibration Test.—An intensive study of data on several types of vibration testing equipment is in process by the members of the committee for the purpose of correlation and standardization of a test method.

Moisture and Water Vapor Resistance.—Research has been complete and a tentative method of test for water vapor permeability of packages has been accepted (D 895 – 47 T). In addition, test methods are being prepared as a result of data collected on water resistance of containers (spray method) and resistance to submersion.

Committee D-11 on Rubber and Rubber-Like Materials

Automotive Rubber.—The A.S.T.M.-S.A.E. rubber compound classifications (D 735) are under continual review, and an important revision adopted this year included the addition of a number of suffix letters used in connection with various tests for these compounds. Detailed specifications and test methods for natural rubber cups for use in hydraulic actuating cylinders (D 818) were issued in 1945. A new method for heat aging of vulcanized rubber or synthetic rubber by the test tube method (D 865) was issued in 1946. This method was based on experimental data published in report appearing in ASTM Bulletin, January, 1945, p. 33. Current work in progress included studies of V-belts, hydraulic brake cups, gaskets, oil seals, engine mounts and other vibration insulators, bumpers, ordnance lubricating gun hose, and conductive rubber.

Chemical Analysis of Rubber Products.—Methods of identification and quantitative analysis of synthetic elastomers (D 833) were issued in 1945. Further investigation of these methods is continuing, particularly on the procedures for determining sulfur, carbon, and cellulose.

Aging or Life Tests of Rubber Products.—Accelerated aging tests of various types of rubber compounds are being made in comparison with natural aging of the same samples. Sections are studying the following four aging tests in current use: (1) methods of aging rubber-like materials such as polyvinyl chloride; (2) air oven testing methods; (3) aging test and data on GR-S types of synthetic rubbers; and (4) correlation and effect of various other miscellaneous properties of rubber and rubber-like materials upon their aging life. This work has a long-range objective of covering thoroughly the problems involved in testing the aging life of many new types of synthetic materials and should lead to very constructive revisions of present methods.

Properties of Rubber and Rubber-Like Materials in Liquids (Immersion Tests).—Rather extensive investigations on evaluating rubber for oil resistance resulted in methods for determining changes of properties of rubber and rubber-like materials in liquids (D 471). Method D 471 was revised in 1946 to provide close tolerances on the test oils in order to insure good reproducibility of results. These changes resulted from cooperative studies of the effect of several reference fuels and 62 octane gasoline on synthetic rubber compounds and reported in ASTM Bulletin, August, 1945, p. 33. The subcommittee is continuing its research on the action of different oils and fuels on rubber and synthetic materials.

Adhesion of Rubber to Metal.—Based on earlier research work, a test for adhesion of rubber to metal was issued (D 429). There is renewed interest in this subject and further studies are now being started. A review of hardness test methods as well as an investigation of other adhesion methods used for the same purpose is being undertaken. A section has been organized to study the testing of adhesion of rubber to metal by the stripping method. This will include an investigation of the effect of the position and angle of shear on the results of the test.

Testing of Liquid Rubber Products, Cements, Latex, etc.—Work previously done resulted in methods of test for viscosity and total solids content (D 553) and methods of testing rubber adhesives (D 816). The shear-type adhesion test described as method B in D 816 is being further studied. A set of classification tables for specification purposes covering cements is also in preparation. This will be similar to the specification for automotive rubber D 735. As a basis for the classification, a cooperative test program using especially prepared cements of known quality is being arranged for the purpose of establishing ranges and limits for the various specified values. The viscosity test methods for cement are being given further study, since the procedure in D 553 has been found somewhat limited in use.

Sponge Rubber.—New developments and applications during the war stressed the necessity of adequate test methods and specifications for various types of sponge rubber. This resulted in completion of Methods D 552 and Specifications D 798 for cellular rubber products. Following further studies both of these standards were revised in 1946. Completed

Hard Rubber and Hard Rubber Products.—Round robin tests are under way on studies of tension, elongation, and impact tests of hard rubber. Samples of high, medium, and low quality compounds being tested. Consideration is also being given to new tests for cold flow and softening temperatures of plastics and particularly their application to hard rubber.

Rubber-Coated Fabrics.—The test program includes a study of abrasion resistance of coated fabrics. Various machines are being investigated including the Taber abraser, Wyzenbllk machine, and American Seating Co. apparatus, and the scrub resistance apparatus developed by the Quartermaster Corps. Other tests under consideration include flexing life and additional hydrostatic pressure tests. Test work just completed resulted in revisions of methods of testing rubber-coated fabrics (D 751) to include bursting strength test, procedure for adhesion tests of coating to fabric, and a hydrostatic resistance test.

Low-Temperature Tests of Rubber and Rubber Products.—With the completion of the brittleness test (D 746), modulus test (D 797), and the thiokol bent loop test (D 736) the original program has been essentially completed. Consideration is now being given to temperature considered necessary for peace time testing, and to the standardization of low-temperature dynamic tests. This latter subject is becoming increasingly important.

Hardness, Set, and Creep of Rubber and Rubber-Like Materials.—This includes an investigation of the currently used methods of testing compression set, with attention to the effect of different variables involved. Study is also being made of a new type of durometer known as the Rex hardness gage. A section on creep determination has also been organized, and work has been started on methods of testing this important property.

Plasticity Test.—This involves a study of methods for determining the processability of rubber and rubber-like materials. Various types of instruments now in use throughout the industry are being surveyed, looking toward standardization of apparatus and test procedures. Data are also being collected on other methods in use throughout the industry for judging processing characteristics of uncured stocks. The future activity on this project will be determined after a study of these data.

Resilience Test.—This project includes the development of methods of test pertaining to resilience, hysteresis, damping, and dynamic stiffness of rubber and rubber-like materials. Study has been undertaken of three main classifications of tests frequently used, namely, rebound, free vibration, and forced vibration.

Committee D-12 on Soaps and Other Detergents

Tests on Soap and Other Detergents.—Cooperative laboratory work on a method to evaluate sulfonated detergents by washing a standard soiled cloth in a launderometer under various conditions is continuing. Research on a method of analysis for loss on ignition of tetrasodium pyrophosphate resulted in the addition of this procedure to Methods D 501. Cooperative study on methods of analysis of soaps containing synthetic detergents has resulted in the publication of Methods D 820. A method of test for free alkali and potassium carbonate in potash paste soaps has been added to Methods D 460. A new section has been formed to work on the problem of evaluation of detergents; specific methods under consideration are lather tests, pH, wetting, surface and interfacial tension, soiled slide test for dishwashing detergents and detergency in general. Analytical methods for sodium bicarbonate and for borax are being developed.

Dry Cleaning Detergents.—A study of methods for evaluating dry cleaning detergents by performance tests is continuing. Work has also been initiated on methods for chemical analysis of drying cleaning detergents and of dry cleaning soaps.

Metal Cleaners.—Cooperative work on methods of chemical analysis of industrial metal cleaning compositions has resulted in the publication of Methods D 800. An immersion corrosion test for aluminum cleaners is to be issued this year. Indirect performance methods of test for metal cleaners are being developed. The Bibliography of Aluminum and Other Metal Cleaning has been expanded and appears in the 1945 compilation of A.S.T.M. Standards on Soaps and Other Detergents. In preparation is a further addition to the bibliography to bring it up to date.

Committee D-13 on Textile Materials

Tests for Bleaching, Dyeing and Finishing of Textiles.—A program is being developed

to carry out needed research on accelerated tests. New materials coming into use are to be studied from the standpoint of fire-retardant properties. A Symposium on Mildew Resistance of Textiles was separately published in 1944. A new tentative method of test for evaluating treated textiles for permanence of resistance to microorganisms (D 862), a test for resistance of fabrics and yarns to insect pests (D 582), a test for resistance to microorganisms (D 684), and a test for fastness of colored textiles to light (D 506) have been completed.

Rayon and Its Products.—Studies are under way of current problems on testing of rayon and its products, such as determining shrinkage of fabrics after laundering, identifying different types of rayon, and the application of the inclined plane tester for rayon yarn, particularly the rate of loading. An importan. contribution in 1946 was publication as tentative of methods of testing and tolerances for rayon tire cord (D 885). An extensive revision of Method D 258 is now under study and methods for continuous filament rayon yarns are in preparation.

Abrasion and Wear Tests of Textile Fabrics.—A cooperative test program includes studies of the Taber abraser, the Wyzenbeek machine, and the U. S. Rubber Co. abrader. Several task groups are conducting studies on various problems. Due to the complex nature of the subject, this will be a long-time project.

Tests of Wool and Its Products.—Intensive work which involved research testing resulted in various test methods and specifications covering fineness, fiber length of wool, and methods of testing various wool products, and cover hearts of wool, pile, filler, etc. The 1942 Report indicated studies under way on effect of tension in reeling on yarn number determination, and interlaboratory tests are being carried out on fineness measurement of top, card sliver, and noils. In the work on pile floor covering the section is preparing a program for research on the correlation of laboratory wear testers with actual service tests for fabrics containing vegetable and synthetic fibers in the pile. Investigative work during the past three years resulted in revisions (in 1946) in the fineness test methods for wool (D 419 and D 472). Methods for the determination of vegetable matter content of wool are being studied and the inter-laboratory studies of the sampling of fleece and the various methods of measuring fineness are being continued. Problems relating to shrinkage are also being investigated. The section on pile floor coverings is studying methods for evaluating intangible factors of luxury, wear testing, tests for kraft cord, and methods of measurement of tuft length.

Felt.—This project involves a study of methods for measurement of hardness, compressibility and compressional resilience of pressed felts, and methods of analysis for synthetic fibers in felts. A report on "Fire-Retardant Properties of Treated Felt" with a proposed specification and a proposed method of test was published in ASTM BULLETIN, January, 1947, p. 66.

Cotton and Its Products.—Investigative studies are being made on the procedures for sampling length, distribution, fineness, immaturity, strength, and cross-sectioning. Methods of test for tire fabrics are being studied, including a method of evaluating adhesive properties of tire cord to rubber. A microscopi method for gage determination is being studied.

Glass Fiber and Its Products.—Projects being studied include twist test procedure, effect of tension in winding on weight of glass yarn, effect of jaws on breaking strength of glass yarn, determination of sizing properties, and preparation and handling specimens for breaking strength tests.

Methods of Testing Textile Fabrics.—Projects being studied include hand and draping qualities of soft woven fabrics, yarn numbers of fabrics, accelerated aging, soiling properties, basic fabric properties, and test methods for elastic fabrics. Proposed Methods of Test for Evaluation of Properties Related to the Hand of Soft-Finished Woven Fabrics published as information.

Committee D-14 on Adhesives

Fatigue.—A very active study on fatigue testing has been under way. At least seven laboratories are cooperating, and the work will be coordinated through Committee E-9 on Fatigue.

Preparation of Test Specimens.—Efforts are being made to originate new concepts of specimens for obtaining the physical constants for adhesive bonds. This work involves stress analysis, both graphical and mathematical, and deals with composites in metal. Tests must be developed to meet facilities of small laboratories.

Effect of Cyclic Humidity and Temperature Changes on the Permanence of Adhesive Bonds.—A group in Committee D-14 is actively engaged in determining accelerated cycles that will forecast the ability of an adhesive bond to withstand severe exposures. In this work the committee is very much aware of the needs of the armed forces as well as the ordinary industrial consumer.

Integration of the Cleavage Test as Related to Tension Test.—A round robin study has been completed and is now being analyzed.

Development of Tests to Measure Flexibility Properties of Adhesives.—This problem involves the important concept of trying to differentiate among cleavage, tension, and flexibility in adhesive bonds. A flexibility test has been conceived but is not in effect.

Rate of Cure.—This work is being actively carried out at the present time at Frankford Arsenal in accordance with a program instigated by the committee.

Speed of Testing.—With the wide variety testing machines, it has become quite important to analyze fully the question of speed of testing on data obtained. This problem is being worked on primarily at the Massachusetts Institute of Technology under Prof. A. G. H. Dietz who heads the research subcommittee. The problem of the committee is that of making test methods general.

Concept of Tack.—There is a very active group engaged in fundamental work on the determination of tack. This problem involves the meeting of physical chemistry and practical production engineering in a most complex manner.

Nature of the Adhesive Bond.—A group is engaged in analyzing the present theories explaining how adhesives stick. This work involves the use of tools and techniques such as the electron microscope, X-ray diffraction studies, and surface phenomena

Physical Strength Properties versus Geometry of Joints.—Some work done on the analysis of the geometry of the adhesive bond as related to ultimate breaking strength has led to results completely divergent from existing practices. It is necessary to continue very actively in this field of adhesives in order to make test data interpretations rigorous.

Statistical Analysis.—The committee is engaged in using statistical analysis for indicating the validity and practicability of some test methods.

Determination of the Elastic Constants Such as the Modulus of Elasticit and the Modulus of Rigidity.—The committee is working on a means of determining a stress-strain function.

Creep of Adhesive Bonds.—As most adhesives fall into the field of plastic-like materials, the phenomenon of flow becomes very complex. Work is being done on analyzing this important consideration which, it is hoped, will result in a good test method. Creep is very difficult to measure in adhesives.

Effect of Artificial Light, Fungus, Etc.—A tentative method on the effect of artificial light on the permanence of adhesives, and reports on the effect of termites, rodents, etc., on the properties of adhesive bonds have been presented. Round robin studies have been continued along these lines.

Aromatic Hydrocarbons, Water, Plastics

Committee D-16 on Industrial Aromatic Hydrocarbons

Distillation of Industrial Aromatic Hydrocarbons.—A cooperative test program is under way on five aromatic hydrocarbons (1 benzene, 2 toluenes, 3 xylenes) to determine the degree of usefulness of the Tentative Method of Test for Distillation of Industrial Aromatic Hydrocarbons (D 850). Members of Committees D-16, D-1, and D-2 are cooperating in these tests. The program includes the study of different types of flasks and thermometers in order to determine which arrangement of apparatus gives most reproducible results.

Copper Corrosion Tests of Aromatic Hydrocarbons.—Some fundamental studies on copper corrosion methods directed toward the development of a quantitative method for measuring the amount of sulfide corrosion are being undertaken and a cooperative test program is planned to determine its practicability.

Committee D-17 on Naval Stores

Properties and Tests of Rosin.—The study of methods for determining unsaponifiable matter and petroleum spirits insoluble matter in rosin are continuing. The work on crystallization tendency of rosin has been discontinued. Research on the other subjects listed in the 1943 Review has resulted in the preparation of tentative methods for analysis and testing of tall oil (D 803), dipentene (D 801), pine oil (D 802), pine tars and tar oil (D 856).

Acid Saponification Number.—The determination of acid and saponification number of dark rosins is a special problem on account of the masking of the colorimetric end point

in the ordinary titration. The solution of this problem is progressing by use of an external indicator. In the case of the saponification number, however, this has not proved practicable or accurate. Neither has it been possible to obtain satisfactory results by means of electrometric methods of ascertaining the end point in a dark rosin-alkali solution.

Volatile Oil in Rosin.—Incomplete distillation and removal of higher boiling fractions of turpentine, from the pine oleoresin, also of mineral oil solvents used to extract rosin from still waste or resinous wood, has resulted in very soft, low melting, unsatisfactory rosin. A tentative method (D 889) which has been developed permits an accurate determination of such excess volatile oil.

Water in Liquid Naval Stores.—Certain uses for liquid naval stores products such as pine oil, dipentene, pinene, and turpentine, require a practically anhydrous material. The quantity of water present, even at high concentration, runs not over about 1.0 per cent on pine oil, less on the hydrocarbon terpenes. An adaptation of the Karl Fischer method for water, using the reagent containing pyridene, methanol, iodine, and sulfur dioxide, has proved satisfactory for determining accurately the water content of most liquid naval stores, and is now issued as Method D 890.

Methods for Evaluating Rosin Oils.—A cooperative test program is being developed to study methods for evaluating rosin oils.

Committee D-18 on Soils for Engineering Purposes

Soil Stability Under Triaxial Loading.—Research is in progress and a summary of work accomplished will be presented at the 1947 Annual Meeting.

Committee D-19 on Water for Industrial Uses

Analysis of Industrial Water.—The project reported in the 1943 review is continuing. Through interlaboratory tests and cooperation a number of methods applicable to industrial waters have been developed including: sampling plant or confined waters (D 510), reporting results of analysis (D 596), sampling boiler water from stationary boilers (D 860), test for total aluminum and aluminum ion (D 857), determination of calcium ion and magnesium ion (D 511), determination of chloride ion (D 512), determination of total carbon dioxide and calculation of the carbonate and bicarbonate ions (D 513), test for dissolved oxygen (D 888), determination of hydroxide ion (D 514), test for manganese (D 858), determination of total orthophosphate and calculation of the respective orthophosphate ions (D 515), test for silica (D 859), determination of sulfate ion (D 516).

Boiler Feedwater, Particularly Caustic Embrittlement.—As reported in the 1943 review, this work is carried on primarily under the sponsorship of the Joint Research Committee on Boiler Feedwater Studies, which is sponsored by six societies, including A.S.T.M. Based on this work, Committee D-19 published, last year, a Method of Field Test for Tendency of Boiler Water to Cause Embrittlement Cracking of Steel (D 807–46 T). Present work at the Bureau of Mines involves the tabulation and interpretation of experience information sent in by specific plant operators, insurance companies, and water treating companies who have agreed to cooperate in this effort. The objective is to assemble experience records which, it is hoped, will either verify or possibly disprove some of the arguments which originated in the Joint Committee's work respecting the cause and prevention of embrittlement.

Water Formed Deposits.—A recommended practice for sampling of water formed deposits (D 886) was completed in 1946 and the committee is proposing in 1947 a method for application of X-ray diffraction methods and a method for reporting results of analysis. The study still continues and two papers dealing with this subject will be presented at the Annual Meeting in June.

Committee D-20 on Plastics

Strength Properties of Plastics—Work is under way on tension tests of rods and tubes, falling ball impact test, shear test, stiffness tests of nonrigid plastics, bearing strength, and bending strength. Round robin tests are in progress on a number of these subjects.

Hardness Properties of Plastics.—The method for evaluating abrasion resistance by means of the Taber abrader is being actively studied by 12 laboratories. Studies made of Rockwell Hardness test are given in the report of the D-20 spring meeting in the ASTM Bulletin, March, 1947 (p. 39).

Thermal Properties of Plastics.—Methods for determining ignition temperature are being studied as described in a paper by E. M. Schoenborn and D. S. Weaver, Jr., to be published in the ASTM Bulletin. This will supplement the flammability tests, methods D 568, D 635, and D 757. Round robin tests are under way on flow of thermoplastic materials. Studies are also under way in five laboratories on test for determining changes in heating. Tests for coefficient of volume expansion using an invar cell are being investigated.

Optical Properties of Plastics.—Problems being studied include surface irregularities, diffusion of light, testing for haze, index of refraction, and related characteristics. Three proposed methods for measuring haze, in various stages of completion, include the spectrophotometer, sphere-hazemeter, and the Hunter Null-method hazemeter.

Permanence Properties of Plastics.—Consideration is being given such problems as effects of light, heat, water, and chemicals on plastics, also shrinkage on aging. Procedures for accelerated service conditions (D 756) have been completed.

Analytical Methods.—Round robin tests are under way on determination of plasticizer, residual solvent, pigment, and filler in cellulose ester plastics. Work is to be undertaken on development of methods of testing plasticizers including procedures for acidity, purity, specific gravity, and color.

Impact Testing of Plastics.—A basic study is being made of the factors entering into the concept of brittleness (or toughness) as distinguished from strengths expressed by results of static tests, that is, tension, flexure, etc. The excess swing method (Izod or Charpy) now standard for plastics is being critically examined with a view to eliminating well-known defects. Concurrently several radically different methods are being investigated as possible alternatives to, or substitutes for, the excess swing method.

Flow.—Fundamental study of flow phenomena in plastics with a view to eliminating some of the present confusion resulting from a plethora of flow tests of an empirical nature. It is an attempt to establish, once and for all, the precise mechanism of flow at various temperatures so that plastics technologists can speak a common language with regard to this very important property.

Testing, Analysis of Metals, Fire Tests, Building Constructions

Committe E-1 on Methods of Testing

Consistency, Plasticity, Viscosity, and Related Properties.—This work has included the preparation of a test method for softening point by shouldered ring-and-ball apparatus (E 28). Important contribution was a 1937 Symposium on Consistency (separately published). Of interest on this project is the E. C. Bingham Memorial Symposium on Rheology held on November 1 and 2, 1946, at the 1946 meeting of the Society of Rheology. A collection of information has been made of all known methods for determining the softening point and melting point. A similar collection of methods of determining absolute viscosity is now in preparation. These various test procedures will serve as a basis for further standardization.

Particle Size Measurement.—Cooperative studies of particle size tests are intended to develop information on the fundamental validity and experimental reproducibility of microscopic measurements. The program of the committee also includes studies by electron microscope, optical microscope, and gas adsorption.

Indentation Hardness and Hardness Conversion.—With the issuance of conversion tables for cartridge brass (E 33) and for steel (E 48), this project has been completed. At some later date, further work may be undertaken on extending the conversion tables for steel and possibly developing hardness conversion tables for other nonferrous metals. When such work is undertaken, new projects will be set up.

Hydrogen Ion Concentration.—Various problems dealing with measurements of pH value are being studied, including the fundamental theory of such measurements. An important contribution was the 1946 Symposium on Hydrogen Ion Measurements (separately published); also new A.S.T.M. method for determination of pH of aqueous solutions with glass electrode (E 70).

Committee E-3 on Chemical Analysis of Metals

Methods of Chemical Analysis.—Cooperative research, in much of which the National Bureau of Standards is participating, is being carried out on methods for chemical analysis of the following metals: (1) Steel (for boron, beryllium, aluminum, and tin). (2) Copper-nickel-zinc and copper-nickel alloys (for copper, nickel, cobalt,

zinc, iron, lead, tin, and manganese). (3) Tin- and lead-base alloys (photometric method for aluminum). (4) Zinc-base die-casting alloys: (*a*) polarographic method for lead, cadmium and tin; (*b*) electro-analysis for copper (with automatic voltage control); (*c*) photometric method for iron, nickel, and manganese. (5) Electronic nickel (in cooperation with Committee B-4 (6) Monel metal. (7) Aluminum (photometric methods). (8) Copper (for beryllium).

Committee E-5 on Fire Tests of Materials and Construction

Fire Hazard of Acoustical and Similar Finishes.—The research project on fire hazard classification of acoustical and other materials for interior finish is continuing. Special attention has been given to the more flammable finishes and methods by which their flammability can be reduced, using readily available materials and methods.

Effect of Size of Samples for Fire Test.—Some general results of the work on effect of size and border conditions of sample on fire endurance tests were given in the discussion of the paper on "Fire Resistance and Thermal Properties of Concrete Slabs" (ASTM *Proc.*, Vol. 43, 1943, p. 1148). Further information on the general subject is being obtained from results of fire tests being conducted in connection with other projects.

Tests for Incombustibility.—As informative in connection with developments of definitions, an experimental study was made of the British test and definition for incombustibility (British Standard 476–1932).

Fire Tests of Roof Constructions.—Fire tests of roof constructions were undertaken independent of A.S.T.M. by the National Bureau of Standards in cooperation with the steel roof deck industry. Eleven fire tests were conducted in the smaller equipment at the Bureau and two in the larger furnace to determine the difference, if any, in criteria of acceptance of roof structures as compared with floors. These tests were used as a basis for revision of Standard Method E 119 as pertaining to roof deck constructions.

Fire Tests of Columns.—Some fire tests of protected structural steel columns are to be undertaken during the year to obtain more specific information on the range in scope of application of the new proposed tentative method of fire tests of structural steel columns under which the performance is defined by the temperature in the column steel instead of failure under an applied load.

Fire Tests of Wood.—In connection with the development of test methods for wood given partial or surface treatment, it will be desirable to conduct tests to obtain information on methods of sampling. A comparable series of tests was conducted and previously reported (*Proc.* 1941, p. 238) as a basis for the present method (E 160) and the new tentative method using the fire tube (E 69).

Committee E-6 on Methods of Testing Building Constructions

Building Constructions.—The committee, formed in 1946, in its initial developments is planning to depend upon the substantial research data and background in the building field obtained from the large number of agencies which have carried on such work, such as corporations, universities, National Bureau of Standards, and the Forest Products Laboratories in the United States and Canada. Further, the committee plans to take advantage of active research in building construction under way at the present time and to suggest fields in which further research of interest and value to the committee should be undertaken. A tentative method for conducting strength tests of panels for building constructions has now been formulated and presented for acceptance.

Definition and Measurement of Gloss

Dr. V. G. W. Harrison has written a very useful and important book, and I think all workers in colorimetry will find it worthy of study. The literature on the subject of gloss has been surveyed from the early writers through its present status. However, the book is far more than just an annotated bibliography, since the various theories and methods for measurement are discussed in a sympathetic, yet critical manner. This work will be welcomed by those concerned with the practical evaluation of gloss, because it explains why instrumental readings often disagree with visual comparisons.

The work is divided into four parts: (1) physical factors influencing our sensations of gloss; (2) types of gloss classed according to the sensations experienced by normal persons; (3) methods for the practical determination of gloss; (4) discussion on present status of the subject.

Part 1 deals exclusively with the reflection of light from surfaces in a very understandable and nicely illustrated manner. Also included is an interesting mathematical treatment explaining the non-uniform reflectance of light by wavy surfaces. Part 2 distinguishes the various types of gloss recognized by observers. In addition, the phenomena of binocular luster, metallic luster, and the luster of gems are discussed with special reference to the physiological and psychological factors involved. Part 3 describes the various methods for measuring gloss. The methods are grouped according to the type of instrument used. Part 4 presents a discussion of the whole problem and emphasizes the distinction between the sensation of gloss and the physical properties of the surface which gives rise to the sensation. Dr. Harrison suggests two approaches to the measurement problem: one, the equivalent stimulus method, and the other, the determination of some type of reflectance measurement that will correlate to a useful degree with the type of gloss in question.

Published by the Printing and Allied Trades Research Assn., London. This book of 145 pages, with 31 figures and tables is available at 10 shillings.

Walter C. Granville

Fundamentals of Plastics

There is an institution in this country known as the progressive dinner. First the guests go to the Ignatz Gottzlebub's where Ignatz serves his well-known Gottzlebub Killer, a tasty cocktail consisting of two parts glacial acetic acid and one part goat's milk. Then the mob moves to the Widow O'Bannion's where she serves her famous Mulligatawny soup which she flavors with sprigs of garlic and a few dashes of Uranium 235. The soup is kinda strong as old man O'Bannion proved some years ago when he died from eatin' too much of it. Then to the Worthington-Pottfoots for the main dish and so on through the dinner. This is the system used by H. M. Richardson and J. Watson Wilson in compiling their book. Each subject is covered by an expert in his line. Like the progressive dinner, the book lacks the smooth continuity of a fashion show at the Waldorf. On the other hand, it carries an authenticity not possible with a single author. In addition to Richardson and Wilson, long-established names in the plastics field lend eminence to its various parts, i.e., Gloor and Ball on the cellulosics, Adams and DuBois on molding, Stock on testing, etc. The book was not written for advanced study by so-called experts. Of necessity it is a rehash of presently known technology. It is obviously slanted at the man who wants a general and authentic picture of plastics, their chemistry, manufacture, fabrication, uses, economics. For such a man it is a good book. Furthermore, reading it will do the expert no harm. He'll be surprised how many things he should have known but didn't. The book is available from McGraw-Hill Book Co. at $5.

Robert Burns

Engineers' Council for Professional Development

The Engineers' Council for Professional Development, which has its headquarters in the Engineering Societies Building in New York, has issued its Fourteenth Annual Report. This report gives a description of the organization of this Council, its activities, and lists of accredited schools. There are reports of a number of the E.C.P.D.'s committees on professional recognition, company ethics, conditions, etc. The objectives of this Council which was formed on October 3, 1932, are: "To coordinate and promote efforts to attain higher professional standards of education and practice, greater solidarity of the engineering profession, and greater effectiveness in dealing with technical, economic, and social problems."

This Program is Subject to Change

All time indicated is Eastern Daylight Saving Time

Provisional Program

FIFTIETH ANNUAL MEETING

of the

AMERICAN SOCIETY FOR TESTING MATERIALS

ATLANTIC CITY, N. J. CHALFONTE-HADDON HALL JUNE 16 TO 20, 1947

	Morning	*Afternoon*	*Evening*
Monday, June 16	Committee Meetings	Committee Meetings	*1st* Symposium on Load Tests of Bearing Capacity of Soils
Tuesday, June 17	*2nd* Symposium on Measurement of Entrained Air in Concrete	*3rd* Soils *4th* Symposium on Insulating Oil	*5th* Technical Papers on Cement and Concrete
Wednesday, June 18	*6th* Electrodeposited Coatings and Metal Polishes	*7th* Presentation of Reports of Committees C-1 to C-18, D-4, D-8, E-5, E-6 *8th* Symposium on Synthetic Lubricants, Reports and Technical Papers *9th* Round Table Discussion on Speed of Testing 4:30 p.m. *10th* Marburg Lecture—"Engineering Laminates," W. C. Voss	Annual Dinner President's Address, Guest Speaker, Awards
Thursday, June 19	*11th* Technical Papers on Plastic Deformation of Metals *12th* Symposium on Rubber Testing	*13th* Symposium on Rubber (Continued)	*14th* Presentation of Reports of Committees B-1 to B-7, B-9 *15th* Round Table Discussion on Water-Formed Deposits
Friday, June 20	*16th* Fatigue of Metals, Effect of Temperature *17th* Presentation of Reports of Committees D-19, Jt. Comm. on Boiler Feedwater, D-5, D-6, D-10 to D-14, D-17	*18th* Presentation of Reports of Committees A-1 to A-10, D-1, E-1 to E-4, E-7, E-8, E-11, Jt. Comm. on Filler Metals *19th* Plastics and Wood	

Monday, June 16 8 p.m. First Session

Symposium on Load Tests of Bearing Capacity of Soils

In recent years load tests to measure the bearing capacity of soil masses have become of increasing importance in engineering practice in spite of wide diversity in test procedures, methods of analysis, and application of results in design. The use of this type of test received great impetus in the wartime airfield construction and in the postwar evaluation programs. Even though some engineers have condemned load tests as unreliable, they strike the practical mind as a direct and objective approach to a major problem for which there has been no generally accepted analysis. After a lapse of several years in the attempt of the Society's technical committee to formulate a standard test procedure it is the purpose of this symposium to review the great volume of factual data that has been accumulated during these years and renew the efforts to bring order out of chaos by a concerted and realistic attack on the problem. The symposium will be introduced by a report of the symposium committee on the Compilation of Current Procedures in Conducting Load Test, and résumé of papers and opinions submitted to the symposium committee.

Field Loading Tests for the Evaluation of the Wheel Load Capacities of Airport Pavements. L. A. Palmer, Navy Department.

The paper discusses the test procedures and test data obtained in connection with an airport pavement evaluation project sponsored jointly by the Bureau of Yards and Docks and the Bureau of Aeronautics of the Navy Department. The paper is primarily concerned with but one phase of the project, loading tests.

Loading tests were made both on the flexible pavements and on the subgrade. The general procedure followed in evaluating the wheel load capacities of pavements is described. The relations among loading test data, pavement thickness, and subgrade properties are illustrated.

Methods of Testing Soils for Runways and Foundations. Elwyn E. Seelye, W. D. Bailey, and S. D. Teetor, Seelye, Stevenson and Value.

Attention is paid to the various methods of testing and evaluating tests.

Correlation studies are given for rolling load tests, plate load tests, C.B.R. results based on Army tests. A comparative study of the results of different methods of evaluation is given for the specific problem of the Southwest Philadelphia Airfield (Hog Island).

Details of testing equipment are given.

The authors' perspective on foundation tests and design is discussed.

The Use of Load Tests in the Design of Flexible Pavements. W. H. Campen and J. R. Smith, Omaha Testing Laboratories.

This paper describes a method for utilizing load tests for the design of flexible pavements. Rigid circular plates are used to represent tires of equivalent contact areas and load-bearing evaluations are made at ½-in. total deformation.

By the use of three plates load-bearing values are determined on the natural subgrade and superimposed layered systems. A graph is then constructed showing the variation of unit load-bearing value with size of testing plate as well as the strength imparting power of the superimposed layers.

The data on the graph are used to calculate thicknesses necessary to handle desired loads on tires of different sizes and inflation pressures.

Field Bearing Tests Applied to Pavement Design. Robert R. Philippe, War Department, Corps of Engineers.

A Cyclic Load-Test Procedure. Jean E. Hittle and W. H. Goetz, Joint Highway Research Project, Purdue University.

This paper describes a method of conducting loading tests with a cyclic-loading procedure. This cyclic-loading test procedure establishes the load-rebound as well as the load-deflection relationships throughout the loading test; in addition, the combination of these two relationships establishes the amount of permanent deformation that takes place as the bearing test progresses. A special loading plate is described which, in conjunction with the cyclic-loading procedure, provides for the determination of deflections, both elastic and permanent, occurring in the subgrade soil, as well as those occurring in the base material. Sufficient data are presented in support of the test method to establish reliability of the procedure and to show differences in the soil and base types that are not revealed by conventional loading procedures.

A Canadian Investigation of Load Testing Applied to Pavement Design. Norman W. McLeod, Department of Transport, Ottawa, Canada.

By means of repetitive load tests on subgrade, base course, and surface, a method of design for thickness of flexible pavements has been developed, which is tied in with runway service performance under aeroplane traffic in Canada. The influence of repetitive loading and bearing plate size on the value of subgrade modulus k for rigid pavement design is shown. Useful correlations are indicated, by means of which limited load test data can be extrapolated to other bearing plate sizes, and to any deflection over the range of at least 0.0 to 0.7 in. Subgrade load-test data have been correlated with cone bearing, Housel penetrometer, field C.B.R., and triaxial compression tests.

PAPERS ON RADIOGRAPHY—Monday, June 16, 8 p.m.

At a technical meeting of Committee E-7 on Radiography the following two papers are being presented. All those interested in these papers are cordially invited to attend.

Radiation and Safety. C. H. Hastings, *Watertown Arsenal*

Sensitometry of Radiographic Films Exposed to Two Million Volt X-Rays. E. A. Burrill, *High Voltage Engineering Corp., and* W. W. Buchner, *Massachusetts Institute of Technology*

Tuesday, June 17 9:30 a.m. Second Session

Symposium on Measurement of Entrained Air in Concrete

At present there are two A.S.T.M. methods for measuring the quantity of air entrained in concrete, one, a standard and the other a tentative method. Since they were devised, several other very ingenious methods have been developed and have been given extensive practical use. It now seems possible to compare these methods for accuracy, simplicity of operation, and practicability for use in the field, to the end that an entirely suitable method or methods may finally be standardized by the Society. It is hoped that facts revealed by the present symposium will lead to that desirable result.

Procedure for Determining the Air Content of Fresh Concrete by the Rolling and Pressure Methods. Carl A. Menzel, Portland Cement Assn.

Describes apparatus and procedures for determining the air content of fresh concrete based on two different principles, neither of which requires weighing scales. These methods are:

1. *Rolling Method*, a direct volumetric method in which the entrained air is removed by rolling the concrete in an excess of water and is indicated directly by the volume of liquid required to restore the original liquid level.
2. *Pressure Method* (proposed by W. H. Klein and Stanton Walker) in which the volume of entrained air is indicated by the change in volume of the concrete upon application of a known pressure.

The paper includes a proposed tentative for each method based on the extensive studies which were made to develop the proper apparatus, calibration, and testing technique for making the methods as practical and dependable as possible under job conditions.

A Method for Measuring Entrained Air in Fresh Concrete. P. D. Miesenhelder, State Highway Commission of Indiana.

The subject of measuring the quantity of entrained air in concrete is discussed with particular reference to the so-called "Indiana Method" in which the air in the concrete sample is removed by washing with water. Advantages and weaknesses of the method, which has now been in use during two construction seasons, are described.

The Measurement of Air Entrained in Concrete. John H. Swanberg and T. W. Thomas, Minnesota Department of Highways.

This report includes a description of the Klein-Walker pressure apparatus used in both laboratory and field by the Minnesota Department of Highways.

The data include a comparison of results by the pressure method and the unit weight method and also a comparison of results using three different gage pressures and various aggregates.

The data and field experience indicate the pressure method to be dependable, accurate, and convenient.

Comparison of Methods of Measuring Air Entrainment in Concrete. C. B. Schweizer, Corps of Engineers, David Pirtz, and Alexander Klein, University of California.

A comparison of several methods of measuring entrained air in concrete is presented, based on tests at the University of California. Three methods—gravimetric, Indiana, and pressure—are compared on the basis of accuracy, speed, convenience, economy, and suitability for field use. Reproducibility by each of these methods and by the A.S.T.M. (volumetric) method was determined by several operators.

Measurement of Air Contents of Concrete by the Pressure Method. H. W. Russell, Illinois Division of Highways.

The sources of error in air-content determinations of concrete based upon field weighings of samples of known volume are discussed briefly, and the desirability for development of a method of greater accuracy and simplicity is pointed out. Apparatus, made from a magnesium alloy to obtain greatly reduced weight, for use in determining air contents of concrete by the pressure method, and the procedure of testing are described in detail. Summaries of experimental data are presented which show that the test pressure adopted within the limits considered (5 to 30 psi.) is immaterial; that variation in volume of the test samples, as may be occasioned by differences in the strike-off operation, do not influence the results materially; and that a high degree of uniformity of test results is obtained.

Analysis of Methods of Measuring Entrained Air in Concrete. W. A. Cordon and H. W. Brewer. United States Bureau of Reclamation.

Since the advent of entrained air in concrete, a number of methods have been devised to determine the amount of air entrained in a concrete mixture. The general methods now in use may be listed as: (*a*) gravimetric (unit weight), (*b*) pressure (air meter), and (*c*) displacement.

Because of the widespread use of air-entraining agents in concrete construction today, there is an apparent need for evaluation of the various methods in use. The advantages, disadvantages, and limitations of the various methods are discussed. A comparison of the methods is made by statistical analysis of test data.

The Pycnometer Method for Determining Entrained Air in Concrete. J. C. Pearson, Lehigh Portland Cement Co.

This paper reviews briefly the development of the pycnometer test for entrained air as the basis of Method C 173–42 T, and the more strictly volumetric method described in the report of A.S.T.M. Committee C-9 on Concrete and Concrete Aggregates for 1944. Most of the text is devoted to a discussion of errors that are involved in the methods outlined, and suggestions are offered for eliminating the sources of error or for minimizing their effects.

Ohio Method of Determining the Amount of Air Entrained in Portland Cement Concrete. J. F. Barbee, Ohio Department of Highways.

The Ohio method is an adaptation of what is commonly known as the hook gage or Indiana Method, employing scales weighing to 0.01 lb. Ohio already had some one hundred Concrete Control Kits in use which contained all the equipment necessary for the air content determinations except the hook gages. A careful operator, capable of making simple mathematical computations accurately, is required. In the hands of such an operator, the results with the Ohio method check sufficiently closely with those obtained by the pressure method to warrant its use as a field test for air content on a state-wide basis.

Tuesday, June 17 2 p.m. Third Session

Held Simultaneously with the Fourth Session

Presentation of Report of Committee D-18

Technical Papers and Report on Soils

Report of Committee D-18 on Soils for Engineering Purposes. E. J. Kilcawley, Chairman.

The Use of the Maximum Principal Stress Ratio as the Failure Criterion in Evaluating Triaxial Shear Tests on Earth Materials. W. G. Holtz, United States Bureau of Reclamation.

Recent research studies by the Bureau of Reclamation on the shear characteristics of soils led to the selection of the maximum principal stress ratio as the failure criterion for evaluating triaxial shear tests. The article shows the relationships which exist between axial strain and the principal stresses, volume change, and pore pressure during the application of load to shear specimens. The correlation of these factors, at failure, is the basis for the acceptance of the failure criterion. The article also includes brief discussions on the equipment and procedures used by the Bureau of Reclamation, and the effect of pore pressure, as related to the analysis of triaxial shear test data.

Uplift Soil Pressure on Bridge Foundations in Clay Revealed by Shear Tests. G. O. Kerkhoff and W. S. Housel, Michigan State Highway Department.

For the past ten years the Michigan State Highway Dept. has been conducting shear tests as a part of soil investigations for bridges and major excavations. The use of shear test data has become routine procedure in the design of structures and depressed roadways. These studies have provided a correlation between the "ring shear" and the unconfined compression tests revealing the effect of varying the rate of loading.

Performance of the structures themselves as compared to design assumptions have been observed and several examples can now be presented. Pressure cells were installed to measure actual soil pressures in footings to check design figures.

Tests for Thermal Diffusivity of Granular Materials. William L. Shannon and Winthrop A. Wells, Harvard University.

This paper presents the procedures, analyses, and results of tests to determine, using a simplified test procedure, the thermal diffusivity of several granular materials of types frequently used for base course construction of highways and airports. Determinations were made with the materials in the frozen and unfrozen condition at several different unit weights and water contents. From the test data obtained, the volumetric heat capacity and the thermal conductivity for each thermal diffusivity determination were computed. The method, where used to determine the thermal conductivity, is relatively simple and inexpensive in comparison with the more precise methods generally used, yet results of tests on one material using the simplified method and a precise method compare very favorably.

Tuesday, June 17 2 p.m. Fourth Session

Held Simultaneously with the Third Session

Symposium on Insulating Oil

This symposium is the second session of a series of symposia on insulating oil sponsored by Subcommittee IV on Liquid Insulation of A.S.T.M. Committee D-9 on Electrical Insulating Materials. The first session was held on October 16, 1946. Other sessions will follow on appropriate occasions in conjunction with future meetings of Committee D-9 and its subcommittees.

These symposia are chiefly concerned with the intrinsic qualities of an oil for electrical insulation and a discussion of laboratory tests that will allow accurate appraisal of a new oil or an oil in service with reference to its continued serviceability.

It is generally recognized that certain standardized tests are very useful in appraising an oil but in many cases the accurate correlation of test data to actual performance is yet to be established.

The first objective of the present session of the symposia is to analyze the merits of inhibitors in insulating oil to improve performance principally in transformers and cables. There is generally a great incentive to accept the use of inhibitors to extend the useful life of an oil but there are known limitations of substantial moment at the present time. All producers and consumers will be greatly interested in this subject.

The other subject for treatment in this symposium is the power factor test on oil and its significance in appraising serviceability in transformers and cables. In these discussions it is the intention to show the meaning of oil power factor data and accelerated aging tests in judging quality and serviceability of both new oil or oil in service. One paper will treat the significance of oil power factor testing from the approach of the scientist in a research laboratory, and one paper will deal with the more practical application of the tests and the relation to other observations pertaining to the actual deterioration of oils in service.

Introduction. E. A. Snyder, Socony-Vacuum Oil Co., Inc.

Advantages of an Inhibited Transformer Oil. T. E. Reamer and R. G. Larsen, Shell Development Co.

The factors which lead to the deterioration of transformer oils in service are discussed. Numerous accelerated tests for measuring the stability of such oils are considered together with criteria of evaluation. One procedure developed by the authors is described in detail.

Increased oil life has been attained by the addition of an appropriate inhibitor to a suitably refined stock. Numerous data from laboratory and full-scale tests are presented which demonstrate that greatly improved stability can thus be achieved without the impairment of other essential properties.

Oxidation Inhibitors in Electrical Insulating Oils. Leo J. Berberich, Westinghouse Research Laboratories.

The petroleum industry has made substantial progress in the last ten years in the development of inhibited insulating oils. These oils show significantly better oxidation stability in laboratory tests than the conventional oils now in use. Inhibitors, however, have not yet come into extensive use in insulating oils, despite the fact that they are widely used in other petroleum products. Some of the problems which the electrical industry faces in attempting the general use of inhibited oils are reviewed. Specifically, the following subjects are discussed: (*a*) the complex nature of petroleum hydrocarbons, (*b*) the influence of refining on the properties of insulating oils, (*c*) the mechanism of oxidation and oxidation inhibition, (*d*) laboratory test results on a group of representative inhibited oils, and (*e*) practical considerations pertaining to the use of inhibited oils in electrical apparatus.

Power Factor of Electrical Insulating Oils—Significance of and Methods of Testing Stability. J. C. Balsbaugh, Massachusetts Institute of Technology.

Electrical insulating oils are widely used in the electrical industry in condensers, cables, transformers, and other oil-insulated or oil-impregnated apparatus. The power factor of an oil has been used for a long time as an indication of quality and serviceability. In the case of cables and condensers the magnitude of the power factor is important in determining heating, and accordingly must be considered in determining permissible loadings and ratings. For mineral oils which are essentially nonpolar, power factor is directly related to the ionic content of the oil. Accordingly, it may be used as an over-all indication of deterioration and serviceability. The power factor of a mineral oil may be used to determine the polar or nonhydrocarbon constituents, the stability under various oxidation conditions, the effect of contact materials, the stability under ionization conditions, and the presence of deleterious oxidation products. The methods of making power-factor stability tests, the test equipment used, the significance and analysis of results and new test methods that may be used for studying the mechanism of deterioration are discussed.

Serviceability Tests on Transformer Oil from the Viewpoint of the Maintenance Engineer. F. J. Pohnan, Commonwealth Edison Co.

Transformer oils are not stable either chemically or electrically. When subjected to service conditions they change their chemical characteristics and electrical properties. They age and deteriorate. Since there is no unit of deterioration, we cannot measure it nor express it as a definite numerical quantity. The problem of determining the further serviceability of an oil in service can therefore be approached only indirectly by measuring some of the readily determined properties of the oil, like power factor for example, with the assumption that there is a definite relation between the measured properties and the oil serviceability. So far, no such relation has been established and the interpretation of the test results is still left to "judgment, based on experience" of the maintenance engineer. This leaves the maintenance engineer in a profound quandary when it comes to such questions—is it or is it not safe to operate a certain transformer with the oxidized oil, or shall I retain this used oil in service or shall I discard it? It also demonstrates the very urgent need for some general agreement and standardization of criteria with well-defined limits for the oil oxidation products and electrical properties to be tolerated as proofs of serviceability, in addition to the standardized test methods now being used.

Tuesday, June 17 8 p.m. Fifth Session

Technical Papers on Cement, Lime and Concrete

The Effect of Blends of Natural and Portland Cement on Properties of Concrete. A. G. Timms, W. E. Grieb, and George Werner, Public Roads Administration.

The paper summarizes the results of tests of concrete made with seven natural cements and a slag cement blended with each of three different nonair-entraining portland cements. Comparable tests of concrete with two air-entraining portland cements were also made. Some of the natural cements contained air-entraining material in sufficient amounts to produce air-entraining concrete when blended with nonair-entraining portland cements. Others entrained very little air.

The tests indicate that, regardless of cement combination, the compressive and flexural strength of concrete at all ages of test is inversely proportional and the resistance to freezing and thawing is directly proportional to the air content of the concrete.

Surface Areas of High Calcium Quicklimes and Hydrates. Howard R. Staley and Sidney H. Greenfeld, Massachusetts Institute of Technology.

As with many particulate materials, there is a paucity of fundamental information regarding the physical character of quicklimes and lime hydrates. The preliminary work reported is a step toward a more complete understanding of these materials. Low-temperature nitrogen-adsorption data, interpreted with the aid of the Brunauer-Emmett-Teller theory, were used to evaluate various methods of slaking "hard-burned" and "soft-burned" quicklimes. Investigated were the effect of calcination in the presence of sodium chloride and the effects on hydration of excess water and solubilizing and desolubilizing agents.

Methods for the Determination of Soft Pieces in Aggregate. D. O. Woolf, Public Roads Administration.

The Chemical Reactions of Aggregates in in Concrete. W. C. Hanna, California Portland Cement Co.

The Effect of Sampling Errors on Unit Weight and Air Determinations in Concrete. J. C. Pearson and S. B. Helms, Lehigh Portland Cement Co.

A test sample of concrete as taken from a freshly mixed batch rarely contains precisely the same proportions of ingredients as the batch itself. On the assumption that the difference in proportions between those in the batch and the sample is confined to the difference in the ratio of mortar to coarse aggregate, the recovery of the latter from the sample enables one to determine the "sampling error," which is arbitrarily defined as the excess or deficiency of coarse aggregate in the test sample. The paper shows how the sampling error may be evaluated, as well as the resulting errors in unit weight and air content. Data from 30 batches of pavement-type concrete are analyzed by the methods outlined to indicate that accurate unit weights and air contents can be derived from small test samples when the sampling errors are determined. Some changes and possible improvements in testing procedure are suggested on the basis of this study.

Wednesday, June 18 9:30 a.m. Sixth Session

Electrodeposited Coatings and Metal Polishes

Some of the Effects of Cadmium, Zinc, and Tin Plating on Springs. John R. Gustafson. Ford Motor Co.

The correct method of cleaning tempered wire springs prior to plating will be discussed. Graphs outlining the effects of hydrogen embrittlement on *S-N* relationships and scatter will be elaborated upon. The ability of the various finishes to resist corrosion from salt spray will be compared. The salt-spray tests include data on the diminishing effects of these finishes to withstand corrosion to salt spray after these finishes have been subjected to elevated temperatures between 400 and 800 F.

Measurement of Metal Polish Performance. Frank E. Clarke and Robert C. Adams, U. S. Naval Engineering Experiment Station.

The development of objective methods for measurement of the essential properties of metal polish and silver polish is presented. Apparatus constructed for testing polishing efficiency and abrasiveness are described and illustrated. Representative data from tests of 14 polishes of various types and qualities are given in statistical tables. This is the first report of the successful application of performance testing in a new field.

Report of Committee B-8 on Electrodeposited Metallic Coatings. C. H. Sample, Chairman.

Discussion on Exposure Test Panels

The papers which constitute this symposium have been written for the primary purposes of educating new inspectors and supplying the reader of inspection reports with a background that will enable him to understand the reports better. Beside reporting present practices, the authors have also offered their thoughts on how they may be improved. It is hoped that further helpful suggestions will be forthcoming in the discussion of these papers.

Rating Exposure Test Panels of Decorative Electrodeposited Cathodic Coatings. W. A. Wesley, The International Nickel Co., Inc.

A system for rating the results of outdoor atmospheric exposure tests of chromium-plated finishes with a nickel or nickel-copper undercoat should be based solely on the appearance of the test panels. Appearance is difficult to define and there is a great need of objective standards to lessen dependence upon the experience and cooperation of inspectors. As a step toward this goal a set of graphical reference standards was designed. A system of numerical ratings to go with these is recommended which is similar to that employed in the recent cooperative exposure tests of the National Bureau of Standards, the American Electroplaters' Society, and the A.S.T.M. The zero of the new scale is set at a higher quality level because the behavior of coatings during the later stages of corrosion is considered of little practical interest.

Inspection of Exposure Test Panels with Nondecorative Electrodeposited Cathodic Coatings. H. A. Pray, Battelle Memorial Institute.

The function of cathodic, electrodeposited metallic coatings used for purely protective purposes is discussed, and the way in which they deteriorate on weathering is described. Rating systems are summarized, with particular emphasis on the methods used for the exposure tests of electrodeposited lead coatings on steel conducted by Subcommittee II on Performance Tests, of A.S.T.M. Committee B-8 on Electrodeposited Metallic Coatings. The information given is intended to be helpful to the evaluator who needs to form an independent judgment of the utility of a coating from a study of reported inspection records.

Inspection of Exposure Test Panels with Nondecorative Electrodeposited Anodic Coatings. Gustaf Soderberg, Graham, Crowley & Associates, Inc.

The corrosion of zinc or cadmium-plated outdoor exposure specimens proceeds in two stages, an initial stage during which minute rust spots may be found which may be significant in corrosion-fatigue resistance, and a final stage during which increasingly large areas are denuded of plate and exhibit rusting. The rusting during the former stage may be evaluated simply by counting the spots, during the latter by placing over the panel a shield of clear plastic ruled so as to facilitate counting the percentage of rusted area. The whole panel should be evaluated, including the edges, because the second stage usually begins at the lower edge.

Wednesday, June 18 1:30 p.m. Seventh Session

Held Simultaneously with the Eighth and Ninth Sessions

Presentation of Report of Committees on Cement, Concrete, Building Materials, Road and Paving Materials

Committee C-1 on Cement. F. H. Jackson, Chairman.

Committee C-7 on Lime. W. C. Voss, Chairman.

Committee C-8 on Refractories. J. D. Sullivan, Chairman.

Committee C-9 on Concrete and Concrete Aggregates. K. B. Woods, Chairman.

Committee C-12 on Mortars for Unit Masonry. Theodore I. Coe, Chairman.

Committee C-14 on Glass and Glass Products. Louis Navias, Chairman.

Committee C-16 on Thermal Insulating Materials. Ray Thomas, Chairman.

Committee C-18 on Natural Building Stones. Oliver Bowles, Chairman.

Committee D-4 on Road and Paving Materials. W. J. Emmons, Chairman.

Committee D-8 on Bituminous Waterproofing and Roofing Materials. J. S. Miller, Chairman.

Committee E-5 on Fire Tests of Materials and Construction. S. H. Ingberg, Chairman.

Committee E-6 on Methods of Testing Building Constructions. L. J. Markwardt, Chairman.

Wednesday, June 18 1:30 p.m. Eighth Session

Held Simultaneously with the Seventh and Ninth Sessions

Symposium on Synthetic Lubricants, Reports and Technical Papers

Committee D-16 on Industrial Aromatic Hydrocarbons. D. F. Gould, Chairman.

Committee D-3 on Gaseous Fuels. A. W. Gauger, Chairman.

Committee D-2 on Petroleum Products and Lubricants. C. Dantsizen, Chairman.

Sectional Committee Z-11 on Petroleum Products and Lubricants. T. A. Boyd, Chairman.

Polarographic Determination of Tetraethyl Lead in Gasoline.

Richard Borup and Harry Levin, The Texas Company.

The TEL in a small amount of gasoline is decomposed in a volumetric flask with hydrochloric acid, the operation being conducted in such a manner that no quantitative transfer of sample extracts is necessary. The only transfer of sample extract from the original reaction flask is that involved in the actual preparation of the polarogram and for this purpose a precise measurement of the solution is not necessary. This polarographic determination of tetraethyl lead in gasoline involves a minimum of manipulation, no complex chemical operations, filtrations, washing of precipitate, etc. Because of the few operations, results are easily repeatable. The method is commendable also for its speed—a single sample can be analyzed within one hour and 35 determinations have been made per man day. Convenient means for controlling temperature and a convenient cell are described.

Symposium on Synthetic Lubricants

It is not intended to portray that synthetic lubricants are fluids or semi-solids, synthesized from hydrocarbon gases or other sources of hydrogen and carbon, but that the materials discussed in this symposium are true chemical compounds which have been blended with additives to produce the balance of properties required.

Speakers from each of the three leading chemical concerns manufacturing materials suitable for use as lubricants will discuss physical properties and test methods peculiar to these fluids. Comparative laboratory and field data will be presented showing advantages of synthetic materials in specialized applications.

Presentations will disclose the limitations of petroleum and how the performance requirements, particularly, of military aircraft influenced the use and development of synthetic lubricants.

The "Ucon" Synthetic Lubricants and Hydraulic Fluids.

J. M. Russ, Carbide and Carbon Chemical Corp.

The "Ucon" synthetic lubricants and hydraulic fluids are finding many varied applications in industry. The lubricants are available in various viscosity grades in both water-soluble and water-insoluble types which are useful where low solvent and swelling effect on various types of rubber, high viscosity index, low pour points and resistance to sludge and varnish formation are desired. Hydraulic fluids for automotive, aircraft, and iindustrial applications are formulated with the lubricants, suitable diluents, and inhibitors.

Synthetic Lubricants from Diesters.

H. R. Stringer and F. J. Glavis, Rohm and Haas Co.

The composition and properties of lubricants made from diesters are discussed. Comparison is given with petroleum lubricants of equivalent viscosity, showing a number of points of superiority of the synthetics. In certain applications, the usefulness of the diesters over a wider temperature range is sufficient to outweigh their greater cost over petroleum lubricants. Some of the uses to which the diesters have been applied are outlined briefly. The possibility of preparing higher viscosity lubricants through the use of (*a*) higher molecular weight esters or (*b*) polymer thickened diesters is discussed.

Synthetic Lubricants for Military Aircraft.

C. C. Singleterry, Bureau of Aeronautics.

Some of the basic considerations for the selection of aircraft lubricants are presented and the limitations of petroleum products for aircraft operation over wide temperature ranges is discussed.

A brief history of the utilization of synthetic lubricants in Naval aircraft is given.

The problem of testing synthetic lubricants is complicated because little basic information is available on their over-all performance characteristics.

Navy experience in performance testing of some synthetic greases is presented.

Some conclusions are drawn as to future trends in synthetic lubricant development based on aircraft requirements and present experience with synthetic lubricants.

Wednesday, June 18 1:30 p.m. Ninth Session

Held Simultaneously with the Seventh and Eighth Sessions

Round Table Discussion on Speed of Testing

This round table discussion is a preliminary step in the direction of a formal Symposium next year. The main purpose is to uncover undesirable features in existing speed specifications and to find the best procedure for correcting them. It is desirable to have discussion of as many viewpoints as time will permit. "Off the record" discussion will be welcomed.

Mr. H. F. Moore will open the discussion with a general interest statement of the problem and his views concerning its solution. A number of other individuals will present the viewpoints of the various technical committees.

Wednesday, June 18 4:30 p.m. Tenth Session

Marburg Lecture

The purpose of the Edgar Marburg Lecture is to have described at the annual meetings of the Society, by leaders in their respective fields, outstanding developments in the promotion of knowledge of engineering materials. Established as a means of emphasizing the importance of the function of the Society of promoting knowledge of materials, the Lecture honors and perpetuates the memory of Edgar Marburg, first Secretary of the Society, who placed its work on a firm foundation and through his development of the technical programs brought wide recognition to the Society as a forum for the discussion of properties and tests of engineering materials.

Engineering Laminates. W. C. Voss, Massachusetts Institute of Technology.

[See News Article on Lecture, p. 8]

Wednesday, June 18 7 p.m.

Annual Dinner

President's Address

Our Stake in Materials Progress

Guest Speaker, Awards

The Philadelphia District Council is sponsoring arrangements for the Annual Dinner as a feature of the Fiftieth Annual Meeting. At this dinner, the retiring President, Arthur W. Carpenter, Manager of Testing Labs., The B. F. Goodrich Co., will give his Presidential Address in which he plans to discuss the progress made by A.S.T.M. as marked by its Fiftieth Meeting and to stress the future outlook, indicating the important relations of research not only in the A.S.T.M. but in all industry concerned with materials. He has been devoting much time to the planning of his address since its prominence in the Fiftieth Annual Meeting will make it of particular significance. An interesting writer and speaker, Mr. Carpenter will incorporate his ideas based upon many years of close contact with research and standardization problems.

An outstanding guest speaker will join the President in the program.

Thursday, June 19 9:30 a.m. Eleventh Session

Held Simultaneously with the Twelfth Session

Technical Papers on Plastic Deformation of Metals

Influence of Plastics Extension and Compression on the Fracture Stress of Metals. D. J. McAdam, Jr., G. W. Geil, and W. H. Jenkins, National Bureau of Standards.

A great obstacle to an understanding of the conditions for fracture of metals is the prevalent misinformation about the influence of plastic deformation on the fracture stress. A prevalent view is that any effect of plastic deformation on the fracture stress is merely anisotropic, and is due to reorientation or change of shape of submicroscopic internal cracks. In this paper it is shown that the effect of plastic deformation is a work-hardening effect, similar to the effect on the flow stress. The evidence is based on tension tests, at room temperature and at −188 C., of specimens from cold-extended steel plate and from previously compressed steel bars.

An Experimental Study of the Propagation of Plastic Deformation Under Conditions of Longitudinal Impact. P. E. Duwez and D. S. Clark, California Institute of Technology.

The theory of plastic strain propagation is reviewed with reference to longitudinal impact. Special impact testing equipment is described by which data have been secured for the verification of the theory. Tests in tension on long wires and on specimens with a gage length of 8 in. are reported. The results of some tests made in compression are presented. The effect of release of loading and reflection of plastic strain waves on plastic strain distribution are considered. The concept of critical velocity is discussed. The anomalous behavior of material for which there is a yield point is presented. The results indicate very satisfactory agreement between theory and experiment.

The Velocity Aspect of Tension Impact Testing. William H. Hoppmann, II, New York Naval Shipyard.

The paper reviews briefly the work done by various investigators of the velocity aspect of tension impact testing and, in particular, describes the Guillotine Impact Testing Machine provided by the Navy at the Material Laboratory in the New York Naval Shipyard, for the study of the effect of moderately high velocities on the impact resistance of materials and minor structural elements.

An exposition is also given of the method of Theodore von Kármán for dealing with the propagation of plastic deformations in solids, together with his concept of "critical velocity."

Utilizing the von Kármán method, the critical velocity for a hard-drawn copper has been calculated. The analysis is given along with experimental verification by test results from the Guillotine Impact Machine.

Plastic Flow of a Magnesium Alloy Under Biaxial Stresses. D. M. Cunningham, E. G. Thomsen, and J. E. Dorn, University of California.

The plastic flow of a magnesium alloy was studied by subjecting tubular specimens to axial loads and internal pressures. In one series of investigations the ratios of the longitudinal and circumferential stresses were maintained constant. Flow stress ($\bar{\sigma}$) and effective strain ($\bar{\varepsilon}$) curves for different ratios of the principal stresses deviated about 10 per cent from each other. These deviations suggest that the idealizing assumptions of a theory of plastic flow of work-hardenable metals are not accurately fulfilled by the magnesium extrusion which was studied.

The generalized theory of plastic flow, applicable when the ratios of principal stress vary during the deformation, was tested by holding the longitudinal stress constant and increasing the circumferential stress. The plastic strains which were predicted from the theory agreed fairly well with the experimentally obtained values. The major source of deviation between the theoretical and the observed strains are ascribed to the idealization of isotropy in the theory.

Intercrystalline Cohesion and the Stress-Rupture Test. H. H. Bleakney, National Research Council of Canada.

Ever since Rosenhain proposed his amorphous cement hypothesis, metallurgists have debated the reason for the brittle, intercrystalline failure of normally ductile metals when slowly elongated at elevated temperatures. This phenomenon has sharply limited the feasibility of extrapolating creep rate curves.

A solution to this problem has become of some practical urgency, in view of the necessarily high stresses and relatively short expected life of gas turbine blades.

The literature dealing with the type of failure under discussion contains much evidence that oxidation is a major influence, and no satisfactory evidence to the contrary.

In this paper, the evidence is presented, an hypothesis is suggested to describe the effect of oxidation, and a method of testing this hypothesis is proposed.

The Progress of Failure in Metals as Traced by Changes in Magnetic and Electrical Properties. P. E. Cavanagh, Cyclograph Services, Ltd.

This is a report of further investigations into electromagnetic changes accompanying fatigue failure in rotating beam tests. The results obtained for various metals demonstrate that easily detectable changes in magnetic and electrical properties occur before failure in samples loaded above the endurance limit. No continuing changes are detectable if the load is below the endurance limit. There is no prospect that this test method can be used to estimate remaining endurance life or evaluate fatigue damage alone. Practical applications are limited to determining whether a metal part will fail in fatigue under service loads in an unreasonably short time.

A Study of the Transition from Shear to Cleavage Fracture in Mild Steel. H. E. Davis, E. R. Parker, and Alexander Boodberg, University of California.

Over ranges of temperature within which there occurred the transition from ductile, shear-type failures to brittle cleavage type failures, three types of specimens were tested: unnotched cylindrical tension bars, 3-in. wide flat bars with saw-cut notches in each edge, and 12-in. wide plates with a central notch at the midsection. The mechanism of fracture is discussed in relation to the variation in shear and cleavage strength with temperature and to the state of stress as induced by notching or deformation. Prestraining at a higher temperature was found to have an important influence on the cleavage strength which in turn affected the ductility at low temperatures, even though cleavage fractures may ensue. The severity of the notch, through its influence on the state of stress, may cause the transition temperature to occur over a range from normal atmospheric temperatures to that of liquid air.

Embrittlement Characteristics of Steel. Arthur B. Wilder, National Tube Co.

Bessemer, open hearth, and electric furnace steels made with various deoxidation practices were rolled into pipe and tested. Charpy impact tests at subzero temperatures, work brittleness tests at ordinary temperatures, and other tests were conducted. Data on deoxidized acid bessemer steel are compared with ordinary bessemer and open hearth steels.

A New Type of Magnetic Flaw Detector. Carlton H. Hastings, Watertown Arsenal.

Nondestructive test methods now available for detecting flaws in ferromagnetic materials are discussed. Reference is made particularly to the problem of detecting cracks in inaccessible surfaces such as the bore of tubes and hollow cylinders. The need for a new method for production inspection of such shapes is indicated. Utilization of an old physical principle is suggested, by which the advantages of several existing test methods can be realized. Preliminary study, development tests, and an evaluation of results thus far obtained using the new method of detection are described.

Thursday, June 19 9:30 a.m. Twelfth Session

Held Simultaneously with the Eleventh Session

Symposium on Rubber Testing

This Symposium will attempt to cover the work that has been done with regard to the physical and chemical methods of test, both on synthetic and natural rubbers, making available to industry the accomplishments of Government and industry during the period of the war, when secrecy had to be maintained. Papers will be presented stressing the importance of standardization in the rubber industry, the work of the Rubber Reserve, and the work of private industry in cooperation with Government laboratories. This information should enable A.S.T.M. and industry to aid very materially in the attempt to standardize methods of testing.

The Significance of Voluntary Standards and Their Status in the Rubber Industry. A. W. Carpenter, The B. F. Goodrich Co.

Progress in standardization of methods of test and specifications in the rubber industry prior to World War II is briefly reviewed with particular reference to the contributions of A.S.T.M. Committee D-11 from the time of its formation and to related activities of other groups working in this field. With the advent of government control during the war and the necessity for immediate development of the synthetic rubber industry, standardization assumed prime importance and was of necessity re-oriented under government direction with full cooperation of all interests concerned. The Symposium which this paper introduces summarizes publicly for the first time many of the great advances accomplished under the government program on methods of test used in the rubber industry. The position of A.S.T.M. in postwar standardization program is also outlined.

Functions of Rubber Reserve, Past, Present and Projected. W. R. Hucks, Office of Rubber Reserve.

This paper deals with the historical background of the giant Government synthetic rubber producing agency, first known as Rubber Reserve Co. and later as Office of Rubber Reserve, Reconstruction Finance Corp.

After development of the historical section, the paper details the tremendous coordination of all segments of the rubber industry and this Government Agency to produce standardized products and standard testing procedures.

The policies set up through these committees also collaborated with the A.S.T.M. committee D-11 on Rubber and Rubber-Like Materials to obtain what is regarded to be the best current program of rubber specifications and rubber testing.

The same procedure of industry and Government coordination was followed for the development of new rubbers and the details of this program are set forth. The magnitude of operations is covered in the latter part of this paper and this covers production figures for all types of synthetic rubber, as well as some idea of the voluminous testing programs that accompanied production.

The detail of the laboratory safety program that is carried out in Rubber Reserve is also given.

In the final section of the paper, the projection of future programs is detailed as well as recommendations for the coordination of the testing development work which this Government Agency has initiated.

(Symposium Continued in Thirteenth Session)

Testing and Grading of Wild and Plantation Rubbers. Norman Bekkedahl, National Bureau of Standards.

A method for the testing and evaluation of wild rubber is suggested for the purpose of stimulating discussion on the subject with the hope that it will later lead to the formulation of an acceptable method. This method in its present form is not suitable for application to the grading of plantation rubber, but it is suggested that certain of the tests and specifications be included in a general method whereby all types of natural rubber can be purchased on the basis of laboratory tests rather than solely by the results of the present-day system of superficial examination.

Development of Methods of Chemical Analysis of Synthetic Rubber. Willard P. Tyler, The B. F. Goodrich Co., and T. Higuchi, University of Akron.

The purpose of this paper is to trace the development of chemical methods of testing synthetic rubber during recent years and to discuss the present status of the methods. Particular emphasis is placed on control and specification methods for testing GR-S. There is some discussion of testing of other synthetics and there is a section on the identification and determination of synthetic rubbers and compounding ingredients in vulcanized rubber compounds.

Thursday, June 19 2 p.m. Thirteenth Session

Symposium on Rubber Testing (Continued)

Development and Standardization of Tests for Evaluating Processibility. Rolla H. Taylor, National Bureau of Standards, M. Mooney, U. S. Rubber Company General Laboratories, and J. H. Fielding, Goodyear Tire and Rubber Co.

Prior to the synthetic rubber program numerous tests had been developed for evaluating some characteristic of processibility but none had been sufficiently standardized to permit its use as a control in the manufacture of GR-S. In order to accomplish this the Mooney viscometer was chosen. Some redesign and a definite procedure for each step in the operation of the instrument were necessary. In addition, a satisfactory recorder, a revised recovery device, and a hydraulic cylinder for closing have been successfully adapted to the viscometer.

Processibility indices in terms of banding time, mill break-down, Mooney viscosities, shrinkage, and rugosity are discussed. The behavior on a laboratory tubing machine and a factory method of evaluation are given.

Developments and Improvements in Methods of Stress-Strain Testing. J. W. Schade, Government Evaluation Laboratory, and F. L. Roth, National Bureau of Standards.

The modifications of A.S.T.M. Methods D 15–41 and D 412–41 for stress-strain testing, which have been incorporated in the current Specifications for Government Synthetic Rubbers, are enumerated and discussed. These modifications were made by a committee comprising representatives of the rubber industry, Government laboratories, and Office of Rubber Reserve. Changes were made in the procedures for mixing, curing, preparation of test specimens, and measuring stress. The improvements in and standardization of stress-strain testing procedures have resulted in the elimination of more than 60 per cent of the variability in testing existing among 16 laboratories in 1944. A new method and machine for stress-strain testing, based on measurements of elongation at constant stress are briefly described. This method has decided advantages over present methods for control testing and research studies.

Standardization of Testing and Inspection in Government Synthetic Rubber Plants. Ludwig Meuser, United States Rubber Co., Robert D. Stiehler, National Bureau of Standards, and R. W. Hackett, Office of Rubber Reserve.

The present uniformity of synthetic rubber production was made possible in large part through the standardization and improvement of testing and inspection techniques. The methods employed in the Government program to standardize these procedures are reviewed.

In the past four years, the Government synthetic rubber plants have developed a precision and accuracy of testing hitherto unknown in the rubber industry. In fact, the point has been reached where the precision of testing is about as good as present methods will permit. As a consequence, further significant improvements in uniformity of production must await the introduction of improved test methods.

The Use of Statistical Methods in Rubber Evaluation. Marian M. Sandomire, Navy Dept., Bureau of Ships.

The use of mathematical statistical methods are briefly discussed in their application to many phases of rubber evaluation, such as in the control of quality of manufactured products, the writing of specifications containing sampling inspection plans, the use of inspection test data, the improvement of materials, the development of test methods, the statistical design of experiments, and the study of material serviceability. Illustrations are cited of problems connected with rubber work in which these methods have made a contribution. Statistical methods serve as an aid in clarifying problems, and in planning the most efficient methods of solving them.

Thursday, June 19 8 p.m. Fourteenth Session

Held Simultaneously with the Fifteenth Session

Presentation of Report of Committees on Non-Ferrous Metals

Committee B-1 on Wires for Electrical Conductors. J. H. Foote, Chairman.

Committee B-2 on Non-Ferrous Metals and Alloys. E. E. Thum, Chairman.

Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys. H. S. Rawdon, Chairman.

Committee B-4 on Electrical Heating, Resistance, and Related Alloys. J. W. Harsch, Chairman.

Committee B-5 on Copper and Copper Alloys, Cast and Wrought. G. H. Harnden, Chairman.

Committee B-6 on Die-Cast Metals and Alloys. J. R. Townsend, Chairman.

Committee B-7 on Light Metals and Alloys, Cast and Wrought. I. V. Williams, Chairman.

Appendix
The Determination of Elongation of Sand-Cast Light Alloy Test Bars. F. M. Howell, Aluminum Company of America

Committee B-9 on Metal Powders and Metal Powder Products. W. A. Reich, Chairman.

Advisory Committee on Corrosion. W. H. Finkeldey, Chairman.

Thursday, June 19 8 p.m. Fifteenth Session

Held Simultaneously with the Fourteenth Session

Water

Round Table Discussion on Identification of Water-formed Deposits

Introduction. C. E. Imhoff, Chairman.

The spectroscope is a useful tool in the examination of water-formed and corrosion deposits. It can be used as a semiquantitative instrument in regard to a majority of the determinations, as well as a qualitative instrument in the detection of traces.

The lack of guiding rules in the selection of names and formulas for various species found in water-formed deposits has led to a confusion and ambiguity among the members of the water-treating fraternity. Enlightenment on the logic and philosophy previously used in chemical and mineral nomenclature serve as a starting point from which to draw up new rules acceptable to the majority.

Some Problems in Nomenclature in Mineralogy and Inorganic Chemistry. Michael Fleischer, U. S. Geological Survey.

The purpose of this paper is to supply a background for the consideration of the nomenclature of the compounds found in studies of boiler scales, corrosion products, and similar deposits met with in industrial engineering practice. A brief historical review is given, in which the development of the nomenclatures of mineralogy and inorganic chemistry is sketched. Present practices in the naming of compounds in these fields are summarized. The problems presented by the phenomena of polymorphism and isomorphous substitution are discussed, with some recommendations. Past and present methods of classification of the naturally occurring silicates are given, with a discussion of the nomenclatures based on them.

Use of the Spectroscope in the Determination of the Constituents of Boiler Scale and Related Compounds. Alton Gabriel and Howard Jaffe, Bureau of Mines.

The use of the spectroscope such as the three-arm bunsen type as a replacement for qualitative chemical tests in the determination of the metallic (cationic) constituents of boiler scales and related compounds apparently has not beeen emphasized.

It is not generally realized that over half the elements yield spectra in the visible range when subjected to *arc* excitation. Included are all the more common metallic elements and many of the less familiar ones as well. Thus a spectroscopic examination of samples will disclose to the analyst the cations to be determined chemically and just as important it reveals (by negative test) constituents that are absent but may otherwise have been determined (and found to be absent) in routine analytical procedures. A knowledge of the principal constituents in solids often aid in their identification by petrographic methods.

The setup of the instrument and its operation will be described.

An Evaluation of the Test Methods for the Determination of Dissolved Oxygen in Deaerated Boiler Feed Water. J. F. Sebald, Worthington Pump and Machinery Corp.

Data representing an investigation of dissolved oxygen test methods for the purpose of selecting a preferred method to be endorsed by the Heat Exchange Institute are presented. The program was sponsored by the Institute and was carried on in collaboration with the members of the Oxygen Test Methods Committee.

Four well-known and generally accepted dissolved oxygen test methods are briefly discussed. Data showing their accuracy when applied to well-deaerated and partially deaerated waters in the presence of negligible amounts of interfering compounds are compared. Limitations of the tests in the presence of significant quantities of commonly occurring interfering compounds, both with well-deaerated and partially deaerated waters are shown.

Data showing the precision of the four test methods when used with low interference bearing water are shown in both tabular and graphic form. A comparison of accuracies and precisions obtainable with one of the interference correcting methods for both potentiometric and starch titration is shown graphically.

Friday, June 20 9:30 a.m. Sixteenth Session

Held Simultaneously with the Seventeenth Session

Fatigue of Metals, Effect of Temperature

Committee E-9 on Fatigue. R. E. Peterson, Chairman.

Endurance Characteristics of Some Copper Alloys. H. L. Burghoff and A. I. Blank, Chase Brass and Copper Co., Inc.

This paper describes the endurance characteristics of copper and several copper alloys, available commercially in the form of rod, as determined in rotating beam endurance tests. Tests were performed on two types of specimens, as carefully polished and as notched. The effect of the notching as influenced by notch radius and degree of working of the metal in the notching operation are discussed. Test results are given for more than one temper for several of the materials. The importance of microstructure in determining the endurance strength of naval brass and manganese bronze is shown, and data are presented to show how endurance strength of hard drawn silicon bronze increases with degree of final drawing.

The Fatigue Characteristics of Copper-Nickel-Zinc and Phosphor Bronze Strip in Bending Under Conditions of Unsymmetrical Loading. G. R. Gohn and W. C. Ellis, Bell Telephone Laboratories, Inc.

A method of test developed by the authors for determining the fatigue characteristics of thin strip metal in bending under conditions of unsymmetrical loading is described. *S-N* curves showing the fatigue characteristics of two of the non-ferrous strip materials widely used in the manufacture of flat springs, namely, extra hard temper Alloy No. 4 copper-nickel-zinc and spring temper grade C phosphor bronze strip are shown for various conditions of unsymmetrical loading. Curves showing the relationship between range of stress and various mean stresses are also given for these two materials.

Fatigue Characteristics of Rotating Beam versus Rectangular Cantilever Specimens of Steel and Aluminum Alloys. F. B. Fuller and T. T. Oberg, Air Material Command, Wright Field.

The High-Temperature Fatigue Strength of Several Gas Turbine Alloys. N. L. Mochel and P. R. Toolin, Westinghouse Electric Corp.

High-temperature fatigue strength is recognized as one of the important properties of alloys used in the gas turbine components which operate at elevated temperature. This paper gives the results of the high-temperature, 1200 to 1500 F., fatigue strength investigations on several alloys as carried out at the Westinghouse Research Laboratories.

Joint Research Committee on Effect of Temperature on the Properties of Metals. N. L. Mochel, Chairman.

The Creep Characteristics of Copper and Some Copper Alloys at 300, 400, and 500 F. H. L. Burghoff and A. I. Blank, Chase Brass and Copper Co., Inc.

This paper presents additional information obtained in a continuing program of creep testing of wrought copper alloys at 300, 400, and 500 F. Creep data, including total creep, creep rates, and relative creep strengths, are shown for four types of copper and several copper alloys in annealed and hard drawn tempers. Tensile properties and comments on microstructure of the test materials before and after creep testing are given.

The various types of copper display important differences in creep strength. Two age-hardenable alloys are found to possess high resistance to creep, but are somewhat brittle at the more elevated temperatures. Additions of tin and aluminum to brass contribute little to creep strength.

Erosive Effects of Gun Blast on Materials—Development of a Strong Brittle Alloy. James A. Broadston, North American Aviation, Inc.

Erosive effects of high-temperature explosive gun blast gases on various commercial materials are illustrated. Tests sought a gun blast tube door material that would not only withstand shock of blast and corrosive effect of highly alkaline gun blast deposit, but also be brittle enough to fracture readily into small pieces harmless to craft when accidentally struck by projectile. A special high-copper magnesium-aluminum alloy, having strength up to 30,000 psi. and elongation of less than 0.5 per cent was developed for gun blast tube doors on aircraft operating at high subsonic speeds in which drag of open ports or projecting muzzles cannot be tolerated if maximum performance is to be attained.

Creep and Creep-Rupture Testing. G. V. Smith, U. S. Steel Corp.; W. G. Bens, Air Reduction Co., and R. F. Miller, Carnegie Illinois Steel Corp.

Friday, June 20 9:30 a.m. Seventeenth Session

Held Simultaneously with the Sixteenth Session

Presentation of Reports of Committees on Miscellaneous Materials

Committee D-19 on Water for Industrial Uses. Max Hecht, Chairman.

Joint Research Committee on Boiler Feedwater Studies. C. H. Fellows, Chairman.

Committee D-5 on Coal and Coke. A. C. Fieldner, Chairman.

Committee D-6 on Paper and Paper Products. L. S. Reid, Chairman.

Committee D-10 on Shipping Containers. T. A. Carlson, Chairman.

Committee D-11 on Rubber and Rubber-Like Materials. Simon Collier, Chairman.

Committee D-12 on Soaps and Other Detergents. B. S. Van Zile, Chairman.

Committee D-13 on Textile Materials. H. J. Ball, Chairman.

Section Committee L 14 on Fastness of Colored Textiles. Jules Labarthe, Jr., Chairman.

Committee D-14 on Adhesives. R. C. Platow, Chairman.

PAPERS ON PAINT—Friday, June 20, 11 a. m.

After the business meeting of Committee D-1 on Paint, Varnish, Lacquer and Related Products, the following two technical papers will be presented. All those interested in these two papers are cordially invited to attend.

Evaluation of Surface Treatments of Steel Prior to Painting (Report of Subcommittee XXIX). Arnold J. Eickhoff, National Lead Co.

Gloss as a Sensation and How to approach Its Measurement. R. S. Hunter, Henry A. Gardner Laboratory

Friday, June 20 2 p.m. Eighteenth Session

Held Simultaneously with the Nineteenth Session

Presentation of Reports of Committees on Ferrous Metals, Paints, and Miscellaneous Subjects

Committee A-1 on Steel. N. L. Mochel, Chairman.

Committee A-2 on Wrought Iron. James Aston, Secretary

Committee A-3 on Cast Iron. J. T. MacKenzie, Chairman.

Committee A-5 on Corrosion of Iron and Steel. T. R. Galloway, Chairman.

Committee A-6 on Magnetic Properties. Thomas Spooner, Chairman.

Committee A-7 on Malleable-Iron Castings. W. A. Kennedy, Chairman.

Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys. Jerome Strauss, Chairman.

Committee D-1 on Paint, Varnish, Lacquer, and Related Products. W. T. Pearce, Chairman.

Committee E-1 on Methods of Testing. W. H. Fulweiler, Chairman.

Committee E-2 on Spectrographic Analysis. B. F. Scribner, Chairman.

Committee E-3 on Chemical Analysis of Metals. G. E. F. Lundell, Chairman.

Committee E-4 on Metallography. L. L. Wyman, Chairman.

Committee E-7 on Radiographic Testing. H. H. Lester, Chairman.

Committee E-11 on Quality Control of Materials. H. F. Dodge, Chairman.

Joint Committee on Filler Metal. J. H. Deppeler, Chairman.

Friday, June 20 2 p.m. Nineteenth Session

Held Simultaneously with the Eighteenth Session

Technical Papers and Reports on Plastics and Wood

Committee D-7 on Wood. Hermann von Schrenk, Chairman.

Influence of Nonhomogeneity of Wood on Its Strength Properties. E. George Stern, Virginia Polytechnic Institute.

The influence of variation in nonhomogeneity, as expressed by variation in specific gravity, within clear wood specimens originating from a stick, plank, bolt, tree, and species on the strength properties of and design data for wood are discussed and illustrated. Consideration of these variations may lead to significant observations. Disregard of these variations may result in misleading test information not truly representative for the material, and thus lead to unsatisfactory design data.

Committee D-9 on Electrical Insulating Materials. R. W. Orr, Chairman.

Committee D-20 on Plastics. Robert Burns, Chairman.

Universal Plastics Testing Machine. G. S. Brown, G. S. Burr, W. J. Gailus, L. D. Lipshutz, J. O. Silvey, S. Yurenka, and A. G. H. Dietz, Massachusetts Institute of Technology.

Values of mechanical properties of many plastics are to a considerable extent dependent upon the rates at which stresses are applied. A testing machine has therefore been built to provide constant rate of crosshead motion, constant rate of load, and constant rate of true strain at crosshead speeds ranging from 0.01 to 25 in. per minute. Control is complete on the loading, unloading, and reversed loading cycles, and is independent of the load or the characteristics of the hydraulic fluid. Loads are measured by resistance wire elements bonded to weigh bars and are recorded electronically.

Hardness and Abrasion Resistance of Plastics. L. Boor, War Department, J. D. Ryan, Libbey-Owens Ford Glass Co., and M. E. Marks, Pittsburgh Plate Glass Co.

This paper is published in the March, 1947, ASTM BULLETIN, No. 145, p. 68.

The Effect of Temperature on Creep of Laminated Plastics. W. N. Findley, C. H. Adams, and W. J. Worley, University of Illinois.

The results of creep tests of two fabric-laminated plastics are reported. The tests were conducted at three different temperatures, 43, 77, and 128 F, for a time interval in excess of 1700 hr. Specimens were tested at several different stresses for each of the three temperatures. The relative humidity of the air surrounding the specimens was controlled at about 50 per cent for tests at all three temperatures.

Dimensional changes under no stress and changes in weight of the material were recorded as well as creep. It was observed that the creep rate at a given time and stress was nearly a linear function of temperature for both materials. At the highest of the three temperatures the weight of the laminate decreased during the creep tests and the unstressed length decreased, while at the lowest temperature the weight and the unstressed length increased.

Science Advancing—the Future of Testing[1]

By E. U. Condon[2]

For many years a close working relationship has existed between the American Society for Testing Materials and the National Bureau of Standards. Bureau men are found on nearly every committee of the Society, and much of the technical work of the Bureau has been directed toward results that are useful to the A.S.T.M. So it is perhaps appropriate that I should report to you upon the work of the National Bureau of Standards—what we have been doing and what we hope to do.

Much of the wartime work of the Bureau has not been publicized, since at the time these projects were under way national security would not permit us to discuss them, and now that the war is over our interest has shifted to peacetime work.

Atomic Bomb Project

The atomic bomb project, for example, had its beginning at the Bureau and essential work in connection with it still continues. When word of the discovery of uranium fission was first brought to this country from Germany in January, 1939, it was some months before the possibility of its application to the making of a military explosive was realized. But when this possibility was suggested to President Roosevelt, he asked Dr. Briggs, then Director of the Bureau, to organize Government-sponsored research in that field. An extensive program was started at the Bureau with the cooperation of several of the universities. After a number of careful studies in 1941, it became evident that further progress would call for a large-scale effort, and it was decided to recommend such a step to the Government. By pure coincidence, those of us who were concerned with the project assembled just after Pearl Harbor to consider what action should be taken. I am sure the effect of Pearl Harbor did not affect our judgment, but it may have affected the degree of support the recommendation received. The project was then expanded on a very large scale, and the Bureau continued to play an important part in its development.

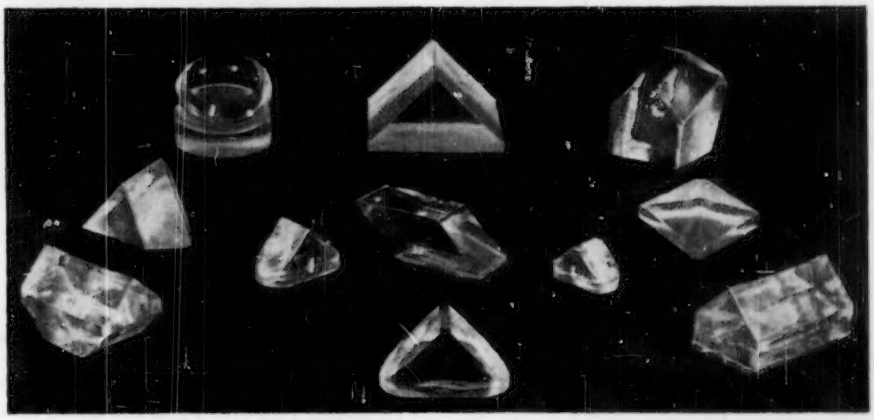
Optical Glass

Another large program of great importance was the manufacture of optical glass, an indispensable item in precision optical instruments for military as well as scientific and industrial use. At the beginning of the first World War, all of the optical glass used in this country was manufactured in Europe. The National Bureau of Standards at that time organized the first production of optical glass in the United States, and production was continued between the wars. Ordinarily the Bureau's work consists only of research and development. However, the lack of scientific knowledge and manufacturing facilities in this field resulted in both wars in the expansion of the experimental glass plant at the Bureau into a manufacturing unit, employing in the recent World War about 600 people. Research and experimental production were carried on simultaneously, resulting in improved equipment, operation methods, and several new types of optical glass for special uses. A technique was originated for molding glass in a shape roughly approximating that of a lens, with a consequent reduction in the amount of grinding necessary for finishing.

Proximity Fuse

The Bureau also had a large part in the development of the radio proximity fuse, officially known as the VT (variable time) fuse, which automatically explodes a projectile at just the right time to cause maximum damage to the target. The proximity fuse is actually a tiny radio sending and receiving set carried in the missile and designed to send out radio waves continuously. When an object of reasonable size is approached, the radio waves reaching the object are reflected back to the projectile. The fuse receiver picks up these reflected waves, analyzes them, and when they have the desired properties (that is, when the projectile is close enough to the object), an electronic switch is closed, detonating the fuse and the projectile.

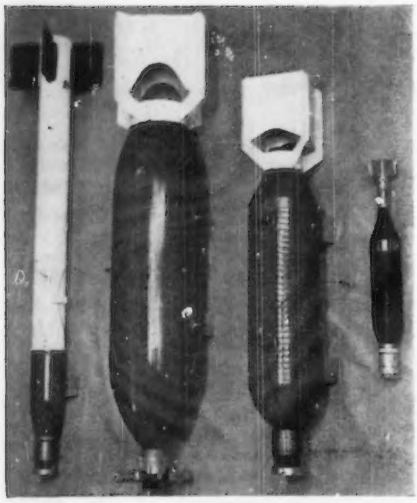
The radio proximity fuse was one of the first weapons sought by the National Defense Research Committee after its formation in August, 1940, as a solution to the threat of



Optical Glass Produced in the Experimental Glass Plant of the National Bureau of Standards Is Molded into Optical Blanks Slightly Larger Than the Finished Piece. The blanks are then ground and polished as required for use in precision optical instruments such as range finders, cameras, and telescopes.

[1] Address presented at the Dedication Dinner held during A.S.T.M. Spring Meeting and Committee Week, February 26, 1947, at the Benjamin Franklin Hotel, Philadelphia, Pa.

[2] Director, National Bureau of Standards, Washington, D. C.



Several Military Missiles with Characteristic Radio Proximity Fuses Developed by the National Bureau of Standards.

At the right is an 80-mm. mortar shell with generator powered radio proximity fuse. Next is a 260-lb. fragmentation bomb with ring type fuse, then a 500-lb. general purpose bomb with bar type fuse, and at the left a 5-in. high-velocity aircraft-fired rocket with ring-type rocket fuse.

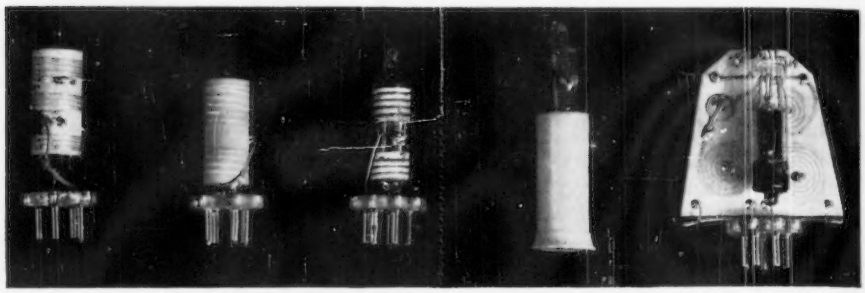
Released for publication by the Army and Navy.

enemy aviation. Under the joint sponsorship of this committee and the Army, a project was initiated at the National Bureau of Standards for the development of a fuse for smooth-bore or nonrotating projectiles—such as bombs, rockets, and mortars. Meanwhile, a large group at the Carnegie Institution set to work on rifled shells or rotating projectiles. The development of this fuse ranks as one of the great scientific achievements of the war. Moreover, the developments and techniques embodied in it may be applied to such peacetime equipment as smaller hearing aids, walkie-talkies, and a variety of other miniature commercial electronic devices.

The requirements of ruggedness and small size in the proximity fuse resulted in the production of extremely minute electronic tubes—smaller than the first joint of the little finger—and the devising of ways of putting extremely rugged miniature radio sets together on a mass-production basis.

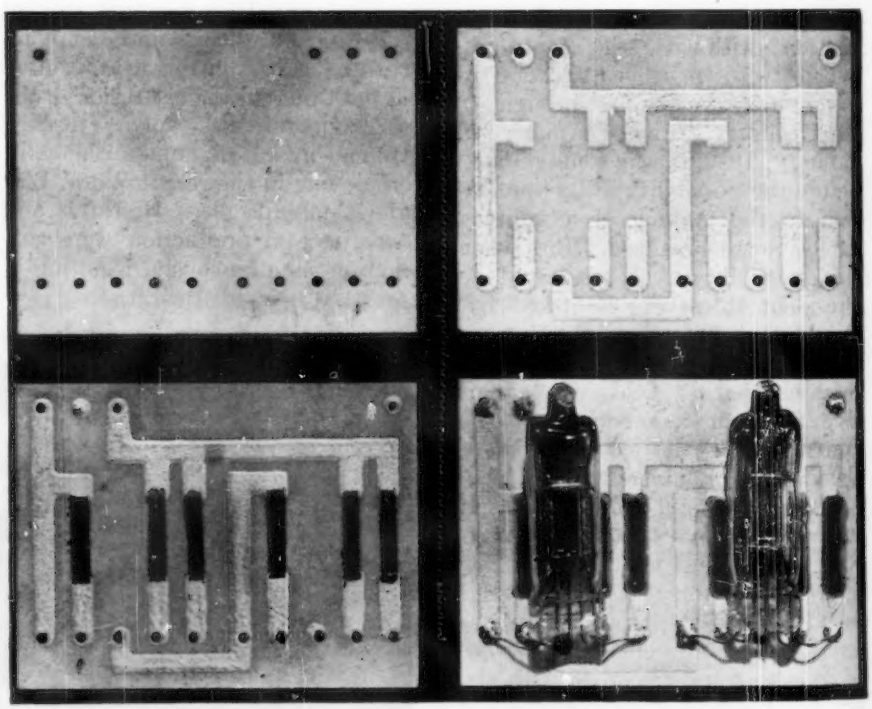
Printed Electric Circuits

One of the most important of the new techniques developed for the proximity fuse was the printed electronic circuit, representing the perfection of a method of printing wiring and circuit components in silver paste on an insulated surface. The methods are applicable in the design of numerous industrial and commercial devices where extreme ruggedness and small size are imperative. By means of the printing process the electronic circuit of a conventional radio—now characterized by a maze of wires, resistors, inductors, and condensers—may be replaced by a compact circuit printed on a small flat plate, eliminating much of the third dimension and making it simple to check and repair. The new techniques promise to simplify production methods and to accelerate the manufacture of



Five Types of Subminiature Radio Transmitters, Utilizing Electronic Printing Techniques, Designed and Constructed at the National Bureau of Standards to Transmit in the 132–144 megacycle Government Band.

All types are grid modulated and require only connection to a microphone and battery to operate. The oscillator circuits of the two units at the left are printed on the outer surface of a thin steatite cylinder housing the subminiature tube. The circuit of the unit at center is painted on the glass envelope of a 6K4 subminiature triode $^3/_8$ in. in diameter and $1^1/_4$ in. long. The transmitter second from the right is painted on the glass envelope of a T-2 tube measuring $^1/_4$ in. in diameter and 1 in. in length. For protection, it is housed in small size lipstick container. The circuit of the transmitter at the extreme right is painted on a $^2/_{32}$-in. steatite plate, $1^1/_2$ in. wide and the same in length.



Four Successive Steps in Making a Printed Electronic Circuit.

A Steatite Plate after Firing and Shrinkage (Upper Left), Plate with Circuit Wiring (Upper Right), and with the Addition of Resistors (Lower Left), and Finally the Assembled Unit with Miniature Tubes (Lower Right). The printed conductors consisting of silver oxide paint are applied through a stencil screen to the ceramic plate. The resistors of graphite ink are applied in the same manner except that their characteristic values are changed by varying their length, width, thickness, and the composition of the ink. The miniature tubes are then soldered into their proper positions.

cheaper, more compact, and more uniform electronic equipment. Other specific applications lie in the fields of pocket radios, personal radio telephones, meteorological instruments, and various miniature electronic control circuits.

Guided Missiles

Another device developed at the Bureau, under the sponsorship of the Navy, was the "bat," the first fully automatic guided missile used successfully in combat by any nation. We hear that the next war will make extensive use of guided missiles. By a guided missile is meant any kind of flying bomb, powered or unpowered, equipped with instruments which enable it to seek out an indicated target and guide itself until eventually it hits the target.

The "bat" is a 1000-lb. bomb mounted in a glider-type airframe and carried under the wing or fuselage of a Navy fighter or bomber. Once the crew of the "mother" plane has located a ship or other target the missile is set for this particular target and the release button is pushed. From then on the "bat" automatically follows every maneuver of the target until it eventually strikes home, while the mother plane is free to proceed as its pilot wishes.

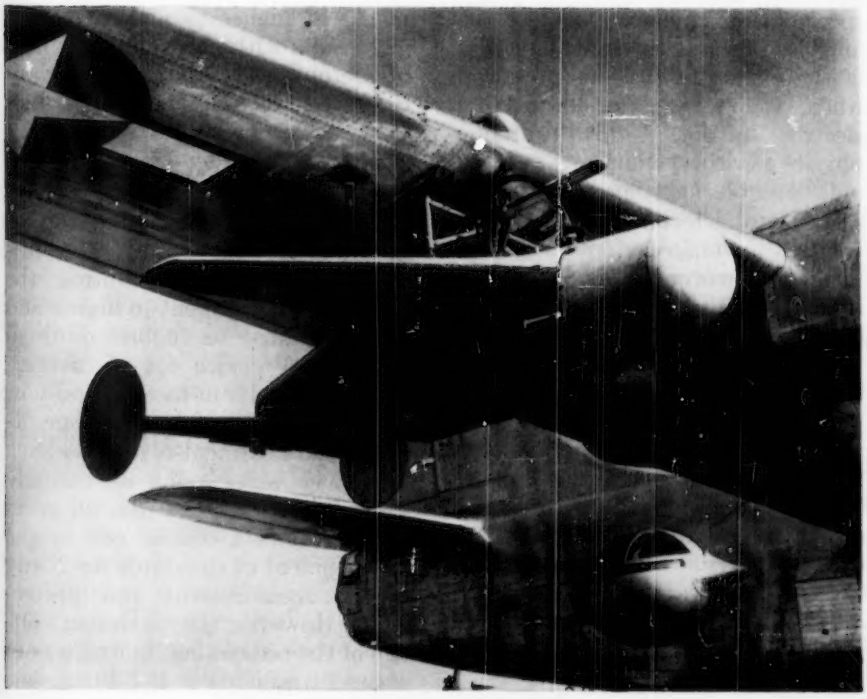
This missile takes its name from the principle upon which it operates. A live bat gives out short pulses of sound and is guided by the echo, thus avoiding collision in the dark. The "bat" missile emits pulses of high-frequency radiation and is directed by the radar echoes from the target. The radar robot pilot can, of course, "see" the target under any conditions of visibility.

Quartz Crystal Oscillators

A bit less exciting, perhaps, than these other things but nevertheless of vast importance in the war effort was the inspection of quartz crystal oscillators, involving the development of inspection methods and the maintenance of a large staff for such work. As you all know, most radio sets used in the war required quartz crystals as frequency stabilizers. Not all quartz crystals, however, are well adapted to such use, and the process of sorting pieces of quartz for suitable oscillators is a highly technical operation. All of this quartz had to be flown in from Brazil and sorted at the Bureau to meet production deadlines. Techniques for its cutting and application were also largely developed at the Bureau.

Prediction Service on Radio Propagation

Still another phase of activity was the development of the prediction service on radio propagation. It is well known that transmission of radio waves beyond the horizon is due to their reflection from the conductive region in the ionosphere. When radio waves travel around the earth, they are not bent, but are propagated in straight lines undergoing alternate reflections by the upper layer of the atmosphere and the ground. Were it not for these reflections, it would be impossible to transmit any but purely local messages. However, the upper atmosphere owes its ionization, upon which its ability to reflect radio waves depends, to solar influences. Thus, the upper region, instead of acting as an ideal mirror, tends to vary in its reflectivity with sun-spot cycles and other little-understood phenomena, so that at times there may be greater reflection of lower frequencies, whereas at other times higher frequencies may be favored. It is apparent that a full knowledge of this subject is of great importance. Although a great number of variables affect radio wave propagation and the distance range, the National Bureau of Standards has developed techniques for the prediction of best frequencies over any specified path three months in advance. This work, which was centralized at the Bureau during the war, with the Army and Navy cooperating, has been transferred to the Bureau completely so that now the Bureau has a number of stations scattered around the world for making ionospheric observations. Through cooperative exchange of data and predictions with other countries, the Bureau's Central Radio Propagation Laboratory is able to predict the best frequencies for communication between any two points. This service is of importance not only in



The Bat

The BAT, the first fully automatic guided missile successfully used in combat, was developed by the National Bureau of Standards in cooperation with other agencies. The BAT is shown mounted under the wing of a Navy patrol bomber ready for flight. Flight characteristics of the carrying plane are only slightly affected by the missile, while flight operations are not in any way altered.

ordinary message transmission but also in the use of radio aids to aerial and marine navigation.

Aside from the work on long-distance communication as affected by ionization in the upper atmosphere, more and more we are coming to use microwaves, which tend to be affected by conditions in the lower atmosphere. Thus the increasing use of higher frequencies makes necessary a vast field of new channels and measurement techniques, and while the Bureau is now engaged in general high-frequency measurement and standardization work, the subject that seems especially to require an approach by a public service institution is the overall study of propagation factors.

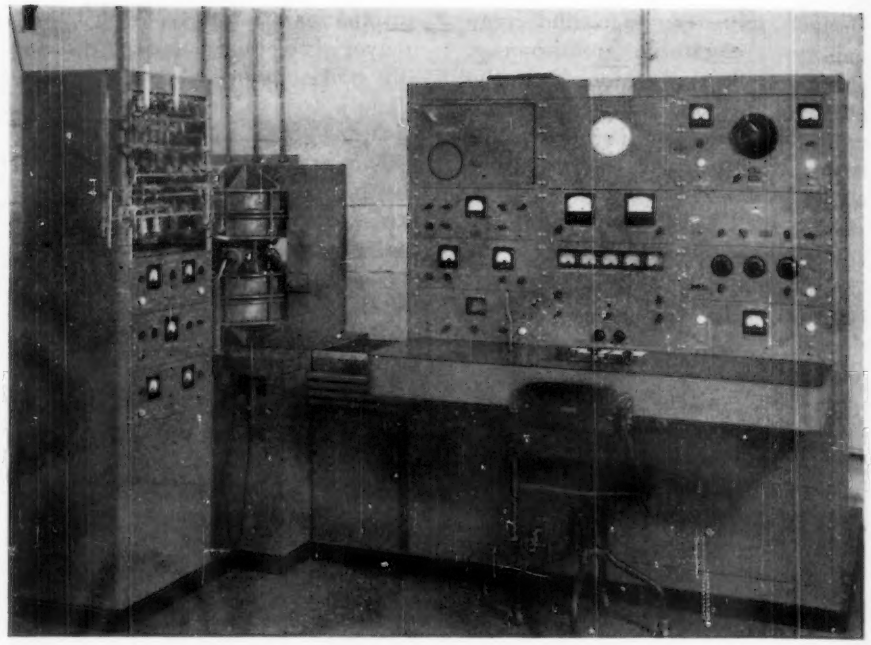
Statistical Analysis Techniques

Another topic that will receive increasing emphasis is the application of the modern techniques of statistical analysis to the Bureau's work in relation to test data and specifications. I am very happy to know that the A.S.T.M. is strongly interested in this subject, too, and has a vigorous committee at work on it.

Quality control methods have been in use for some time, and inspection control and similar techniques were greatly extended in various plants during the war. Nevertheless, in the engineering field we are continually confronted, especially in materials testing, with the construction of expensive sample materials, and we are thus forced to draw conclusions from a very small amount of data, even though the relevant factors are under such poor control that there is large discordance between individual samples. Often the data seem too inadequate to justify valid conclusions. Yet statistical techniques of the past few years have shown that even though an experiment involves a number of uncontrolled variables, still it may be designed so that fairly valid conclusions can be drawn. I feel that this is an important field for us to develop in our testing work, both at the Bureau and in the A.S.T.M.

Mass Spectrometer

Somewhat more in the realm of pure science is the construction, in cooperation with the Office of Naval Research, of a mass spectrometer—a device that detects and determines the masses of both molecules and atoms with an accuracy of several parts in one million. The mass spectrometer makes possible the analysis of gases through the study of the masses of the ions produced when the gases are ionized by electron impact. Used in atomic physics for isotope analysis, it is an indispensable instrument in all the scientific and technical fields where tracers, or "tagged atoms," are applied. However, it is ordinarily limited in its use to molecules of relatively low molecular weight, but we are now constructing a large mass spectrometer for the purpose of extending this work to the more complicated molecules of higher molecular weight such as those occurring in the heavier petroleum fractions and in the broad field of high-polymer chemistry.



Consolidated Mass Spectrometer at the National Bureau of Standards, Used in the Analysis of Gases Such as Hydrocarbons.

This instrument gives a quantitative analysis of gaseous mixtures of almost any composition. The spectrometer is partly behind the gas inlet system (extreme left), and the control panel is shown at right.

Million-Volt Electron Microscope

The Bureau is also engaged in the construction of a million-volt electron microscope. When the electron microscope is used in the usual voltage range, specimens must be extremely thin in order for the electrons to penetrate. We are very fortunate in having the million-volt equipment already at hand for use in X-ray work, and we hope by means of higher-speed electrons to get results with an even wider field of usefulness and thus to do significant research in applied electronics.

Multimillion-Volt X-Rays

The Bureau has also launched a program for the study of multimillion-volt X-rays. During the war radiography went to higher and higher voltages as engineers turned to it as a device for discovering flaws and faults in metals, and now the medical use of high-voltage X-ray in the treatment of diseases such as cancer is becoming increasingly important. For the past 20 years we have had a central role in the development of standards for X-ray dosage measurement and protection. However, the maximum voltage of the present equipment is only about 1.6 million volts. With a view to the extension of research, measurements, and standards development into the 50- and 100 million-volt range, plans have recently been

completed for betatron and synchrotron construction at the Bureau. Betatrons and synchrotrons are devices for producing electrons or X-rays of extremely high energies and frequencies, and they have unusual possibilities in medical, biological, industrial, and nuclear research. Immediate problems for extensive investigation are the determination of measurement techniques and the formulation of precautionary principles in the use of such instruments for cancer treatment.

Protection problems in both medical and industrial applications of high-voltage radiation are much greater in the multimillion-volt region than in the lower ranges. At present heavy protective barriers and expensive over-all installations are being used, but the exact protection requirements are unknown. The Bureau has the responsibility for working out the safety codes for types of construction that will give maximum protection with lowest costs. Industrial use in particular presents difficulties not encountered in the medical applications, and the establishment of safe working conditions for industrial use of such high-energy machines is one of our principal objectives.

Atomic Energy in Industrial and Medical Research

The Atomic Energy Commission is planning for the production of radioactive isotopes for tracer applications, and they will be used, I am sure, more and more in industrial and medical research. The fundamental requirement for this expansion, however, is accurate information concerning the properties of these radioactive elements and the quality of their radiation. Following this there must be available information relating to the chemical and biological behavior of these elements with respect to proposed uses. For example, radioactive elements which in themselves are strongly toxic to a biological organism could not be used as tracers for studies with that organism. Examples similar in principle occur in all applications of tracers. Also, general standard methods of preparing radio-elements for use as tracers must be developed, techniques of measurement evaluated, samples standardized and some guidance in the interpretation of results provided. This field is comparatively unexplored, but we hope to undertake investigations soon.

Electronic Computing Machines

Another project that is well under way at the present time is the further development of high-speed electronic computing machines. During the recent emergency various Federal agencies pioneered in the development and use of ultra-high-speed computing devices. This activity stemmed principally from the efforts of the War and Navy Departments to acquire high-speed machinery constructed specifically for critical wartime computation needs. Three significant developments in this period were (1) an electromechanical computing device of the Harvard Computation Laboratory, (2) the relay-type computing machines of the Bell Telephone Laboratory, (3) and an electronic computing machine (ENIAC) of the University of Pennsylvania. The ENIAC is a very complex device, requiring about 18,000 vacuum tubes. However, the machine is designed so that the tubes are used at less than rated loads, with consequent prolonging of tube life.

The National Bureau of Standards has been commissioned by the Bureau of Census and the Office of Naval Research to construct two high-speed electronic digital computing machines of the latter type, which may well revolutionize the methods of classification and compilation of data and numerical computation.

What are these devices? They are machines to perform very elaborate mathematical computations at extremely high speeds, capable of solving numerically the most complicated differential equations in mathematics and physics. These computers can multiply two 10-digit numbers together in less than a tenth of a second. Now, when a man puts his fingers on a hot stove, it takes something like 200,000 microseconds for him to take his hand away. A human operator is thus too slow to feed problems and data into such a machine. Numbers and orders are taken automatically from a continuous storage medium in the form of a film or tape.

The machines to be built will perform upon instruction predetermined sequences of calculations running into the hundreds of operations without the intervention of human operators. The result will be the solution of problems in days that would take years if attempted with standard machines. These machines are to have built-in "intelligence" capable of distinguishing between orders and information presented in coded form. Design specifications call for internal memories in which 5000 or more 10- or 12-digit numbers and orders can be stored. The machines will be able to transfer numbers and orders between their internal organs and memories within a few millionths of a second. At predetermined steps in computation, the computers will be able to choose and execute alternative orders on the basis of the result of the preceding steps. They will know when computations have been completed to a pre-assigned accuracy and will either print the results at that time or store them on an external tape for printing later.

At the present time, a typical census problem, involving the multiplication of 100,000 pairs of five-digit numbers followed by summing the products, takes approximately 12 working days exclusive of card handling and data punching. The electronic digital machine for the Census Bureau will handle the same sequence in 10 minutes at the most. A problem of great importance to the Navy is the determination of vibration characteristics of ship machinery and aircraft. One such problem arising in the flutter analysis of aircraft wings now takes about 5000 machine hours by the most efficient method available. With the projected Navy computer the problem can be solved in a few hours.

There is a great future for machines of this kind; the surface has been only scratched as yet; and such devices will undoubtedly be of great importance in the scientific background of engineering in the future. Many things in the mechanics of materials, for example, are nonlinear. As soon as we get into

the plastic range, materials cease to behave linearly, and yet all of elasticity theory is based upon linear approximations. From a practical standpoint, mathematical solutions to many such engineering problems are at present impossible, because it would take years to solve the equations involved by present methods. Answers are now found by laborious tests in which the action of one part of a body under test is observed when certain forces are applied at another part. With the new high-speed electronic machines, much of this information will be available in a matter of minutes from the computer, in printed form if desired. The complex computations involved will no longer be beyond the reach of the applied mathematician.

Conclusion

These, I believe, are the more outstanding of the projects that we expect to develop in the near future. We have other broad objectives which I do not have time to detail. For example, we hope to extend our studies of materials and structures for building construction that were interrupted by the war. Again, Congress built an excellent hydraulics laboratory for the Bureau some 10 or 12 years ago. But hardly had this laboratory been established when the war came along, and the building was devoted to the guided missile project. We hope that we shall again be able to do fundamental research in hydraulics in the near future.

I believe that we are entering upon a new period in the development of the subject matter that has been so prominent in the work of the A.S.T.M.—a period in which, through the recent advances in physics, we can expect to obtain a deeper insight into many of the perplexing problems of materials testing with which engineers are faced. With the new developments in atomic theory and new experimental techniques, such as the use of radioactive isotopes, the mass spectrometer, and the electron microscope, as well as the use of electronic calculators for improved analysis of engineering problems, we stand on the threshold of a period in which all these things can be used to develop a fuller understanding of the materials we work with in engineering. This, in turn, should pay large dividends in the way of a better insight into our engineering problems.

The A.S.T.M. will play a great rôle in keeping abreast of these developments. We at the National Bureau of Standards shall try to do our part. Fundamentally the Bureau is a public service institution especially devoted to the needs of the engineering profession, and I hope that, working together, we can show much progress in the years ahead.

Progress in Chemical Industry Through Research and Standardization[1]

By Arthur W. Carpenter[2]

The accomplishments and the value of research both to industry and to the public are widely recognized and have been frequently discussed, *but* less attention has been given to those who carry into practice the results of research and extend the benefits to all mankind. The wartime progress which culminated in the atomic bomb, radar, shells which found their own targets in mid-air, jet propulsion, rockets traveling at incredible speeds, airplanes of tremendous range, load capacity and maneuverability, production of vast quantities of synthetic rubber, toluene, high octane motor fuels, and penicillin, is familiar to scientists everywhere and particularly in this great center of research which has contributed such a large share of the fundamental knowledge on which these great accomplishments have been based.

One should come here, not to talk about research, but to learn of it from those of you who are members of that select group which Arthur D. Little, in talking about the researches of Benjamin Franklin, designated as "The Fifth Estate." Some of you may recall that he said the British Parliament in the time of Franklin was assumed to be composed of representatives of three estates—the lords spiritual, the lords temporal, and the commons; but Edmund Burke, pointing to the Reporters' Gallery, said "There sits a Fourth Estate, more powerful far than they all." Dr. Little then went on to say that Franklin was "a prototype and exemplar of the membership of a 'Fifth Estate,' destined to play an even greater part than its predecessors in the remaking of the World." He then defined this Fifth Estate as ". . . composed of those having the simplicity to wonder, the ability to question, the power to generalize, the capacity to apply. It is, in short, the company of thinkers, workers, expounders and practitioners upon which the world is absolutely dependent for the preservation and advancement of that organized knowledge which we call Science."

Modern Science—A Great Achievement

Modern Science, as we conceive it, is the latest of man's great achievements. It had scarcely gained a footing through all the ages of his-

[1] Presented at a joint meeting of the A.S.T.M. Northern California District and the American Chemical Society, March 10, 1947, at the Claremont Hotel, Berkeley, Calif.

[2] Manager of Testing Laboratories, The B. F. Goodrich Co., Akron, Ohio; President, American Society for Testing Materials.

tory until there occurred in the century before Franklin the great revolution in man's thinking which was epitomized in the work of men like Newton, Galileo, Harvey, Kepler, Descartes, Boyle, and Pascal. Literature and the fine arts—sculpture, painting, and music—were highly developed in ancient civilizations, and a certain degree of mastery of environment had been attained largely by accident or by logic unaided by observation and experiment. It is a curious fact, pointed out by J. B. Bury of Cambridge University, that the idea of unlimited advance never existed anywhere until the last two centuries. The ancient Greek lexicon had no word for progress. The Greeks believed in Necessity, Fate, and Destiny but not in the possibility of sustained progress. To be sure, they had a word for change and there was almost universal acceptance of the theory of cycles and the conviction that history inevitably repeats itself. As Ecclesiastes 1:9 states it: "The thing that hath been, it is that which shall be; and that which is done is that which shall be done, and there is no new thing under the sun." As Heraclitus said, "In the circumference of a circle, beginning and end coincide," and further, "All things flow, nothing abides."

In the seventeenth century all this changed and the foundation was laid for the great subsequent developments in mechanics, astronomy, mathematics and anatomy, but chemical science languished in the hands of the Alchemists. Organizations of scientific men began to spring up with the foundation of the Royal Society in London and the Academie des Sciences in Paris. The new spirit continued and led to a revolution in chemistry based on the work of Lavoisier, Scheele, Priestley, and others, who provided the methods and instruments for the new science. Lavoisier introduced the chemical balance and recognized that weight is neither increased nor diminished in chemical changes, thus laying the foundation for the law of conservation of mass. However, vast experimentation was necessary and it was not until the end of the 19th century that the younger science could attain anything like the completeness of Newtonian mechanics. The atomic theory had to be developed and interwoven with the kinetic theory of gases and extended to form a steady stream of scientific progress.

Meanwhile, men like Carnot, Joule, Helmholtz, and Lord Kelvin developed the principles of thermodynamics, and Coulomb, Franklin, Volta, and especially Faraday among many others contributed knowledge of electricity and magnetism. It was Faraday who saw most clearly the connection between the different manifestations of energy leading to the discovery of the principle of the conservation of energy. In discussing the correlation of the physical forces, Faraday said, "In the pursuit of science, we first start with hopes and expectations; these, we realize and establish, never again to be lost, and upon them we found new expectations of farther discoveries, and so go on pursuing, realizing, establishing and founding new hopes, again and again." Thus, at last, experimental methods were systematically applied, utilizing mechanics, optics, heat, electricity, and chemistry, and the stage was set for the great progress of the last hundred years which through science with its power for good and evil has revolutionized agriculture, food, clothing, and shelter, transportation and communication, warfare and, in fact, our whole material, industrial, and economic life.

Research—"Pure" and "Applied"

Most of the research on which this progress has been based was inspired by a desire to *know*, a search for new knowledge for its own sake without regard to specific applications. It was accomplished because of the scientific curiosity and imagination of the workers and their diligence in pursuing their studies just as far as their abilities permitted. As Harold De Forest Arnold has said: "Research is not constructing and manipulating, it is not observing and accumulating data, it is not investigating or experimenting, it is not getting the facts, although each of these activities may play an indispensable part in it. Research is the effort of the mind to comprehend relationships which no one has previously known and in its finest exemplification it is practical as well as theoretical, trending always toward worth-while relationships, demanding common sense as well as uncommon ability." In this definition of fundamental research, emphasis is properly placed on mental attitude. Nothing is said about design of apparatus, the engineering necessary for commercial application, nor prospect of financial reward. Tangible compensation to the research worker has nearly always been curiously inadequate and his return is in the joy of accomplishment and intellectual satisfaction rather than in material enrichment. Even today with hundreds of millions of dollars spent on research each year, there is more money for the worker, as Dr. Little has said, "in chewing gum than in relativity and the skillful thrower of custard pies in a moving picture studio acquires lobsters and limousines far more rapidly than the no less skillful demonstrator of the projection of electrons. The gate receipts of an international prize fight would support a university faculty for a year."

Once the research work is done or nearly so, there inevitably arises the question of practical utilization of the new knowledge for the benefit of people. Four hundred years ago, Montaigne expressed the idea of teamwork in scientific progress when he said "Where one man fails in experiment, another succeeds. What is unknown in one age is clarified in the next. . . . What my powers cannot solve, I still persist in sounding and trying out. By kneading and working over the new material, turning it and warming it, I make it more supple and easier to handle for the man who will take it up after me. And he will do as much for a third. This is why I should not despair of difficulties or of my own incapacity—for it is only my own." The pure research worker is usually neither desirous of concerning himself with the details of development and production required for application of his new knowledge nor has he the capacity or versatility to do so.

Thus enter the other members of the team, the development and production engineers who take the fundamental data and cooperatively put them to practical use by providing large-scale equipment, introducing process modifications where necessary, standardizing materials and production facilities and establishing methods of measurement and control on all of the diverse factors involved in successful, large-scale operations. It is to this phase of scientific progress that I wish particularly to direct your attention.

Collaboration

Never before in history have scientists and engineers accomplished so much in so little time as during the recent war years. Fighting for time and spurred on by government and industry, collaboration of the team was attained on an unparalleled scale. The achievements have spectacularly shown the results possible from a meeting of many minds in formulating plans, and from the labor of many men in carrying out the programs as finally determined. Such collaboration was not new, since the pattern had been developing in science and industry for nearly half a century. The wartime needs merely made imperative its expansion on a colossal scale to crystallize research, expedite acceptance of compromise, and force wide-spread application, immediately, of the principles of standardization in mass production.

It was for precisely these objectives that the American Society for Testing Materials was formed at the beginning of this century and chartered in 1902 for the "Promotion of Knowledge of the Materials of Engineering and the Standardization of Specifications and Methods of Testing." From the beginning, a basic principle has been the bringing together of all interests involved in any particular problem—researchers, development engineers, consultants, government scientists, producers and consumers—in an organization where agreement on technical problems involving materials can be reached and implemented as standards in a systematic procedure. Often, more research is necessary before sufficient knowledge is available on which to base final standards. Frequently, before the war, full agreement was slow because of the complexity of some of the problems, the diverse interests involved, and the natural reluctance of some of the parties to compromise. Profiting from the war examples where men have seen what can be accomplished under pressure of government in time of dire need, we may hope that in the future there will be an even greater spirit of cooperation and more readiness to sacrifice small selfish considerations for the sake of the common good and the progress of all.

Progress During World War II

It may be of interest to examine rather briefly a few instances of progress during the war in industries at least closely related to the chemical field. There are many from which to chose. Some I shall have to pass because of my own lack of sufficient knowledge concerning them. Perhaps the greatest of all I shall omit both because of my own deficiencies and because the work done here in California has been so comprehensive and so vital as to make unbecoming any comment from me other than an expression of deep admiration for the genius and brilliance of your great scientists. I refer of course to the work on uranium isotopes, nuclear fission, the atomic bomb, and the utilization of atomic energy. Although I realize, too, that there is probably nothing I can tell you Californians about the petroleum industry, I wish to refer to it briefly both because, through the development of synthetic rubber, it has become closely related to the industry with which I am connected and because it is an outstanding example of what happens when research, engineering, and standardization collaborate closely in industry.

Petroleum Advances

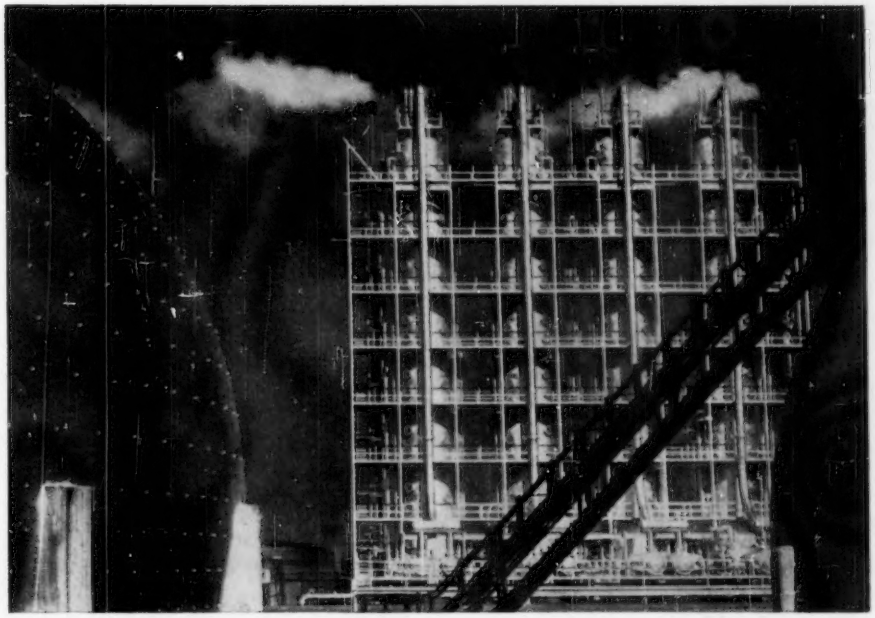
When I was a boy near the oil fields of Pennsylvania, there was practically no research and very little science in the petroleum industry. Even by the time of the first World War, there were barely a hundred technical men engaged in research in that whole industry. The big jobs were getting the oil from nature's storehouse and separating it into its desirable components by distillation and other techniques. Men were worrying about the available supply. The total recoverable reserves of crude oil in the United States were estimated at only about seven billion barrels which, at the rate of production reached just before the recent war, would have been equivalent to only about six years' supply. After 1920, research in petroleum grew by leaps and bounds. Use of scientific methods and instruments for locating new oil deposits, improved drilling methods, better equipment for deeper wells, and methods of retaining underground pressure on the oil sands followed. These increased the reserves so that, although nearly four times the seven billion barrels have been taken from our oil fields since 1918, the proven reserves are today three times as large as was then estimated for the total supply.

Also, introduction of cracking methods and improvements in distillation techniques made available for needed uses a larger portion of the crude material. More recently, the extensive research and development in catalytic cracking, hydrogenation, dehydrogenation, alkylation, polymerization, isomerization, and similar chemical processes have changed the refinery from a plant for separating and purifying the products found in nature to a huge chemical plant in which both composition and molecular structure of hydrocarbons are changed to produce the materials which are most desired. The equipment for carrying out these processes has been brought to more or less standardized design by the engineers of the team who had to solve countless problems involving materials of construction, control of the chemical reactions and purity of the product as well as the many difficulties always experienced in passing from the research stage to the pilot plant and then to large-scale production. During the war, the standardized units were multiplied in numerous very similar installations at suitable locations all over the country. A fluid catalytic cracking plant at Baltimore is a near-twin of a similar plant in Texas or California. Thus the industry made available for our armies and

those of our allies an amazing quantity of 100 octane gasoline which reached a production rate of more than 525,000 bbl. per day. In addition, there were made huge quantities of synthetic toluene for TNT at one fifth the cost of the coal-tar product used in the first World War. Much of the butadiene and styrene for the synthetic rubber used in tires and all of the butyl rubber for inner tubes came from petroleum as well as alcohols and other organic chemicals important not only in war but also in our peacetime industries.

Penicillin—Production Miracle

Another instance of the progress possible through cooperation of scientists, engineers, government, and industry is found in the production miracle which made available in large quantity that most powerful chemotherapeutic agent, penicillin, which has proven so effective in the preservation of human life. Following Fleming's observation in 1929 of the formation by a mold of minute quantities of a bactericidal substance having very low toxicity which he identified as *Penicillium Notatum*, eleven years elapsed before Florey, Chain, and their coworkers reported on the striking therapeutic properties of the new substance. It was an almost impossible task to prepare any substantial amount of it, for the mold grew slowly in broth which had to be protected from contamination while the antibacterial penicillin accumulated in the solution from which it could later be separated under suitable conditions of rapid filtration and extraction at low temperature without exposure to microbial contamination. The process was first carried out in flasks, and the development of plant scale equipment for the growth of the mold and the extraction of the penicillin was a challenge to any chemical engineer because there was no experience in the field to serve as a guide. At the instigation of the Office of Scientific Research and Development, three American chemical concerns who were interested in the research reports from England coordinated their technical and scientific efforts in the field and established a reciprocal arrangement with the English investigators. With increased interest of the Allied governments in penicillin as war medicine, other American firms were encouraged to enter the production picture. More than a dozen firms built plants which stepped directly from laboratory to plant scale operation, and it is to the everlasting credit of all concerned that in the short space of five years the monthly production capacity in the United States has been brought to more than three trillion Oxford units[3] while the potency and purity of the product have been constantly improved and the price of the once rare drug has been rapidly lowered.



Courtesy of Humble Oil & Refining Co.

Catalytic Cracking—Superfractionating Unit at Baytown, Tex., with Spheroid Tanks in the Foreground.

American Rubbers

The story of synthetic rubber is well known today because of its importance in our lives when our supply of the natural material was cut off by the Japanese. Until that happened, many of us hardly realized how necessary to our civilization this prince of raw materials had become. Without it, modern systems of transportation and communication could not function, our health and well-being would suffer, and whole arts and sciences would disappear. Automobiles, trucks, busses, bicycles, and agricultural machines all travel on rubber tires. The modern automobile alone uses rubber in approximately 265 places to give greater comfort and longer service. Airplanes depend not only on tires and tubes for safe landing but also on de-icers for safe flying under adverse conditions and on hydraulic control hose and many other rubber parts which are required for their proper operation. Insulation made from rubber or rubber-like materials guards our power, telegraph, and telephone lines. Rubber footwear and clothing, hot water bottles, and countless medical supplies protect our health. Various styles of hoses and belts convey materials of all kinds and transmit power. Vibrations and noises are quieted, our rides made smoother, and our beds more comfortable by use of this magic material. Yet, it was only a little over 100 years ago—in 1839—that the process of vulcanization was discovered, making possible the successful manufacture and use of rubber products.

Six years ago when we suddenly lost something like 90 per cent of our supply, it was fortunate indeed that the results of many years of scientific research on synthetic rubbers had been brought during the preceding decade to a point where

[3] The Oxford unit is the amount of penicillin which just inhibits growth of a standard test strain of *Staphylococcus aureus* when dissolved in 50 cu. cm. of meat extract broth.

plant scale production was possible. Our greatest military leaders have said that without the marvelous accomplishments in manufacture and utilization of synthetic rubbers the war could not have been won. During the first World War, the Germans had turned to man-made rubber when cut off from natural sources by the British blockade of the seas, but the attempt to use polydimethyl butadiene had very slight success even in the day of limited use of automotive transport and a different type of warfare. This failure, however, led them to further research resulting eventually in the Buna rubbers.

In this country, the peak prices of 1925 and the natural curiosity of scientists to know more about the nature of rubber provided a powerful urge in research which culminated in the development in the early thirties of neoprene and thiokol. These first American rubbers proved very valuable for special purposes such as oil resistance but were too expensive and not well suited for general use. In 1926, the B. F. Goodrich Co. started intensive work on the development of synthetic rubber-like materials. Dr. Waldo Semon and his associates in this program had not only to investigate the possibilities for rubber-like polymers but also in many cases, were obliged to develop the raw materials and practical processes for their production and purification. From this work came many interesting and valuable products, including the well-known plastic, Koroseal. Finally, promising new butadiene-type synthetic rubbers were obtained and in 1937, a pilot plant was built for their production on a semi-commercial scale. In 1941, about 8000 tons of American synthetic rubbers were produced in privately owned plants.

The incredible accomplishment which resulted in an American synthetic rubber industry operating at a rate of more than 1,000,000 tons per year by the end of 1944 was a triumph of cooperation among research men, development engineers, construction men, materials experts, production men, and test engineers. These all worked closely together in government and industry to carry out in the shortest possible time plans which were agreed upon by conference and compromise and adopted as the best available standards for accomplishing the desired objective. All patents and research information available in the various units of industry and government were pooled for the benefit of all. Much has been said and written about synthetic rubber but little emphasis has been given to the part which standardization played and without which the whole program would have failed.

Standardization Essential

One of the first decisions required was the selection, from the many synthetic rubbers which had been made by research workers, of the particular ones to be included in the program. Several general types were possible, including copolymers of butadiene and styrene or butadiene and acrylonitrile, polychloroprene, polyisobutylene, and polysulfide rubbers. After many conferences, much discussion, and considerable compromise, the copolymer of butadiene and styrene in the proportion of approximately 75 per cent butadiene and 25 per cent styrene was chosen for the greater part of the rubber program, the general purpose synthetic GR-S, although smaller amounts of the others were authorized for special purposes. This choice was not fully satisfactory to any of the major interests but was agreed to as the one which most nearly pleased all.

Then came the question of whether the butadiene, which must have a high degree of purity, should be made from alcohol or from petroleum. The former could be gotten into production more rapidly but is much more costly. After much argument, often confused by political and industrial pressures, a compromise was reached whereby a part of the huge program was based on alcohol butadiene to give the earliest possible relief, with the major portion coming along later from the petroleum industry. The alcohol plants have now been the first to be discontinued because of the cost. In passing, it may be

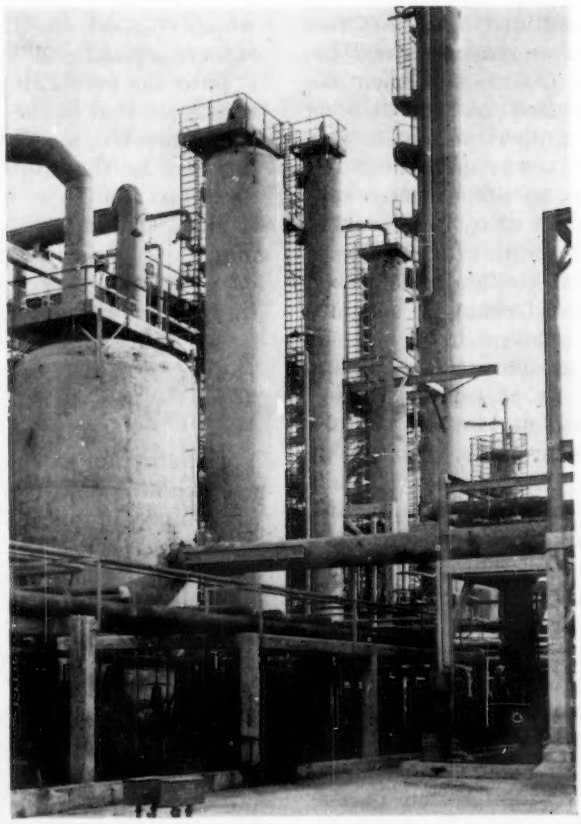
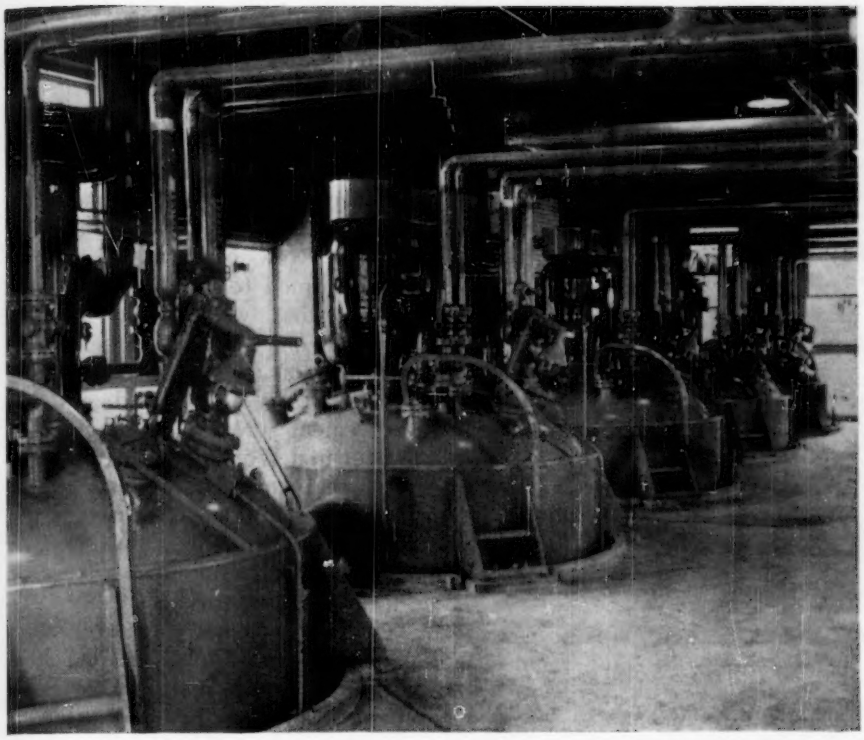


Photo by Rosskam, courtesy of Standard Oil Co. (N. J.)

Chemical Products Division. Fractionation towers of the butadiene unit.

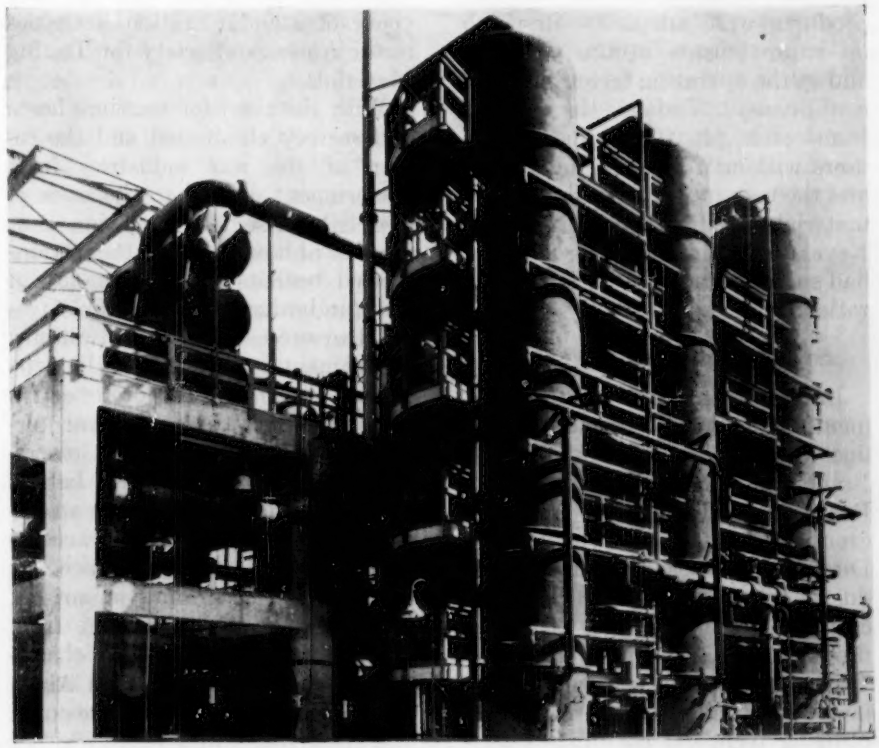


Polymerizers Used in Manufacture of Synthetic Rubber.

mentioned that butadiene from petroleum is made by dehydrogenation of butylene obtained as a fraction in catalytic cracking, while styrene comes from dehydrogenation of ethyl benzene made by the alkylation of coal-tar benzene with ethylene from petroleum. Butadiene is made from ethyl alcohol by dehydrogenation to acetaldehyde which is then converted to croton aldehyde by splitting off water. The croton aldehyde reacts with more ethanol giving butadiene, and water, and regenerates acetaldehyde. Tantalum oxide on silica gel is used as the catalyst.

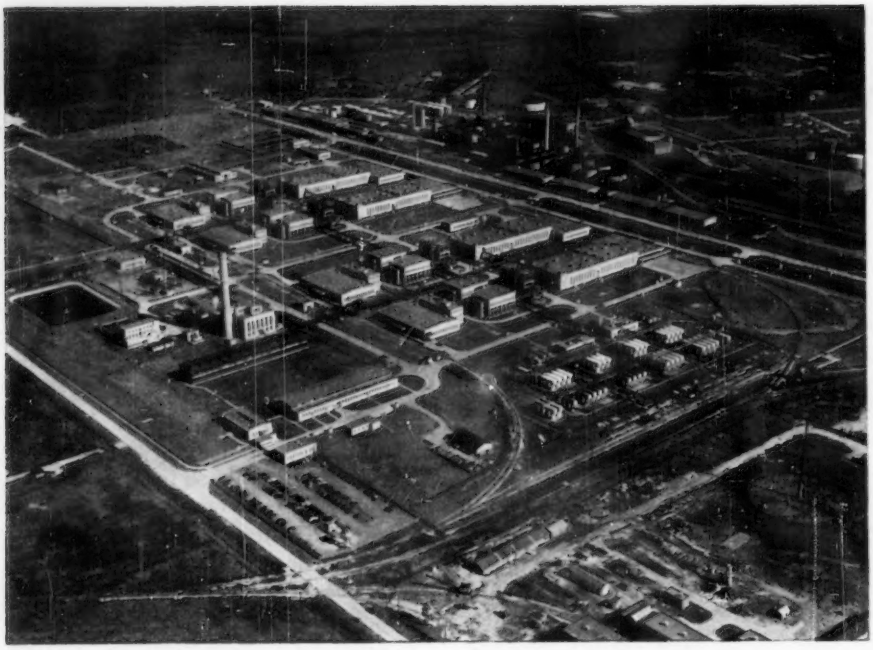
For the polymerization plants which were built and operated by the rubber industry, research and development men who had been through very limited pilot plant experience worked with the best chemical engineers and production operators who could be assembled and brought forth the design of a standard unit plant having a capacity estimated at 30,000 long tons per year and, except for several smaller units and a few minor changes every plant which was built in the million-ton program consisted of multiples of this unit. The polymerization is conducted under pressure at a temperature of 50 C. in the presence of a catalyst and reaches about 78 per cent conversion in 12 to 14 hr. Water and soap as an emulsifying agent together with initiators, modifiers, and stabilizers are added to the blend of the monomers. Unreacted monomer is stripped from the polymerized emulsion before coagulation of the rubber. The standard reactor holds about 4000 gal., and the temperature is closely controlled by a water jacket. The reaction is exothermic. In 1946 Dr. Semon estimated that this process alone used about 7 per cent of the nation's entire soap supply.

These plants when finished went into production with relatively few difficulties and changes, a truly remarkable achievement reflecting great credit to those responsible and to the method employed for their design. However, the quality of the rubber from the different plants was quite variable at first and the rubber processor could often tell by the processing characteristics which synthetic plant had produced the lot in question. So, technical advisory committees, including in membership, experts representing the various interests, were organized and put to work by the Rubber Reserve Co., the Government agency which headed the program, all phases of which were kept highly confidential in the interest of military security. A reference standard laboratory was



Courtesy of Charles Mayer Studios

Stripping Columns for Recovery of Unreacted Monomer in Synthetic Rubber Manufacture.



Courtesy of Elwood M. Payne

Government Synthetic Rubber Plant at Port Neches, Tex.

built in Akron through which standard test methods and data were exchanged by the various synthetic plants. Better standardization and control of both production procedures and methods of quality evaluation were developed. Closer specifications covering all operations from the raw materials to the finished products were adopted. Research on improvements in the polymers and in the operating techniques was continuous. Today, the output from each plant is allocated to users without regard to the source, and the user rarely can tell from the material itself whence it came. Never before in the rubber industry had such a high degree of standardization been realized.

Standardization Pattern

In discussing the rubber program, mention should also be made of the fine work done by the Rubber Branch of the War Production Board and later by the technical group of the Office of the Rubber Director, in spear-heading for industry the many changes in specifications for the thousands of rubber products used all over the land. This work, too, was done by the familiar standardizing technique, utilizing technical committees representing all interests, smoothing out misunderstanding, developing and spreading new knowledge, and reaching compromises which could be tolerated, until, finally, American rubber was able to replace the natural material in the majority of applications. So we see again in the rubber industry a most effective employment of the pattern which had been developed through fifty years of standardization activities in the American Society for Testing Materials.

With the need for wartime haste and secrecy eliminated and the return of the war industries from Government control to the basis of free enterprise, the question now faces us of how to retain the demonstrated benefits in our economy of the standardization procedures fostered so successfully by our military government. Fortunately, the answer is at hand in more effective utilization of those pre-war organizations from which the Government derived its pattern. Let us then turn for a moment to an examination of some of the accomplishments of A.S.T.M., which, by way of illustration and comparison, may show us the direction from which future progress in the chemical industries may come. As Abraham Lincoln once said, "If we could first know where we are and whither we are tending, we could better judge what to do and how to do it."

A.S.T.M. Grows

When the A.S.T.M. was incorporated in 1902, it had as a start some dozen specifications for standard steels which had been developed within the small group of approximately seventy technical men who had been meeting for about four years. New committees were at once formed to do for cement and paint what was already so well started on iron and steel. The number of men cooperating soon grew to several hundred, and the movement spread until by the time of the first World War there were 36 technical committees dealing with different materials and types of test embracing a membership of nearly 2500. Two hundred standards on materials and tests had been developed, and many research projects, to provide much needed technical knowledge, had been initiated. Reports of the committees, papers on research, and the standards adopted had been published in *Proceedings* from the beginning but, by the time of the first World War, the specifications for materials and methods of test had become so numerous, that they had to be published separately in a *Book of Standards* comprising more than 1600 pages. Many important services were rendered to the Government in that war.

Now, the membership is more than 6200 individuals, companies, universities, and government agencies. The Society has a technical, editorial, and executive staff of 42 full-time employees and occupies its own headquarters building on Logan Square in Philadelphia, across from the Public Library, adjoining the Academy of Natural Sciences and close to the Franklin Institute. More than 70 technical committees are actively engaged in research and standardization work on several hundred different materials, developing methods of test and specifications which are of utmost importance to industry and which now require 7000 pages for their publication. During the recent war, the contributions and services to the Government were so great as to merit the Ordnance Department's Distinguished Service Award and the Navy Award of Achievement, which were conferred on the Society

in addition to numerous other awards and letters of commendation to individual committees.

A.S.T.M. and Chemistry

The Society from the beginning has been concerned with the chemical industry. Every chemist is familiar with the long lists in the catalogs of the chemical supply houses, of test apparatus labelled as A.S.T.M. standard. The work of A.S.T.M. in standardizing thermometers, test sieves, and chemical glassware is almost taken for granted. The more recent work on methods for pH measurement, spectrographic analysis, and on photometric and colorimetric methods is perhaps somewhat less familar, although much of this has now been included in a most useful book on chemical analysis of metals which has become an important laboratory tool not only in the metal industries but in other fields as well. Mention should also be made of work in the field of X-ray diffraction, carried out jointly with others, which has resulted in the publication of an 8500-card file of X-ray diffraction data for chemical analysis as part of a Tentative Recommended Practice for Identification of Crystalline Materials by the Hannawalt X-Ray Diffraction Method (E 43 – 46 T).[4]

A number of A.S.T.M. technical committees working in the fields of specific materials and products are directly concerned with specifications and methods of test for industrial chemicals or for products in the manufacture of which industrial chemicals are used. The committee on paint has developed a great number of specifications and test methods for pigments, drying oils, paint driers, thinners, shellac and varnish and lacquer materials, as well as tests for the paints themselves. Committee D-2 on Petroleum Products and Lubricants, one of our largest groups, has not only prepared many methods of test and some specifications covering petroleum products over the entire range of lubricants, fuels, solvents and the like but is now actively engaged in standardizing the application of spectroscopic methods involving ultraviolet and infrared absorption techniques for the analysis of hydrocarbons derived from petroleum. In another committee, that on Gaseous Fuels, an application of the mass spectrometer as an analytical tool is being developed. Time does not permit more than bare mention in other committees of the work on specifications and methods of test as applied to soaps and detergents, adhesives, industrial aromatic hydrocarbons such as benzene, xylene, toluene and solvent naphthas, rubber, and plastics. It must suffice to say that these groups have attained leadership in their fields and where the results of their work have been published by the Society in the form of special compilations of standards, these volumes are generally regarded as authoritative guides for the industries and laboratories concerned.

[4] 1946 Book of A.S.T.M. Standards, Part I-B, p. 865.

Results of Some Society Research Projects

Finally, I wish to mention a group of important research projects of the Society which were initiated in its early days and which are still in progress. Researches sponsored by the Society, jointly with The American Society of Mechanical Engineers, on the properties of metals at high and low temperatures have extended over many years and have aided in the development of metals for the severe requirements of temperature, pressure, and corrosion that are found so frequently throughout the chemical industries. Investigations of corrosion itself and methods for its prevention have constituted a similar phase of the Society's activities. It has been estimated that the loss through corrosion of ferrous metals alone reaches the fantastic figure of two billion dollars annually. Since about 1916, the Society has maintained test racks for exposure tests of a wide variety of metals by means of which reliable data could be obtained on the effect of various methods employed for their protection including such things as control of composition, admixture, and alloying with other elements, coatings of more resistant metals and paints, and control of environment both chemical and electrical. It may interest you to know that two of the present sites are on property made available by the University of California while others are located in widely varying sections and climates all over the country. A vast amount of knowledge has been obtained from these projects which has been invaluable in pointing the way for reduction of the huge loss and in developing reliable methods for test and comparison, since the results are published by the Society from time to time in the form of symposia, technical papers, and committee reports. Such long-time projects can only be carried out successfully by cooperative effort within a stable and continuing organization, but their effect on the progress of science and the advance of civilization is incalculable.

The Final Culmination

In the last analysis, we are all working to the same end, namely, the improvement of the lot of the human race and though as Tennyson says "Science moves, but slowly, slowly, creeping on from point to point," it is possible to expedite the process if we all cooperate and profit from the lessons of the past. Perhaps then we shall see the final culmination envisioned by that same poet nearly a century ago, when he wrote[5]:

> "For I dipt into the future, far as human eye could see,
> Saw the Vision of the world and all the wonders that would be;
> Saw the heavens fill with commerce, argosies of magic sails,
> Pilots of the purple twilight, dropping down with costly bales;
> Heard the heavens fill with shouting, and there rained a ghastly dew
> From the nations' airy navies, grappling in the central blue;
> Far along the world-wide whisper of the south-wind rushing warm,
> With the standards of the people plunging thro' the thunder storm;
> Till the war-drum throbb'd no longer, and the battle flags were furl'd.
> In the Parliament of Man, the Federation of the World."

[5] Tennyson—"Locksley Hall."

Reproducibility of the Single-Blow Charpy Notched-Bar Test[1]

By N. A. Kahn[2] and E. A. Imbembo[2]

SYNOPSIS

In an effort to obtain data which would serve to indicate the reproducibility of the single-blow Charpy notched-bar test, the authors solicited the assistance of seven industrial and Government laboratories in carrying out the tests described in this paper.

Charpy test specimen blanks, completely machined but not notched, were prepared by the authors from a uniformly stress-relieved, low-carbon, semi-killed steel. Each of the cooperating laboratories was supplied with 24 of these blanks and requested to prepare 12 specimens with the keyhole-type notch and 12 with the V-type notch. Six of each type were tested by each laboratory at room temperature; the remaining six of each type were returned to the authors for test at the Material Laboratory of the New York Naval Shipyard. A similar set of specimens was notched and tested by the authors for comparison purposes.

In addition, the temperature-impact relationship of the material for both types of notches was determined on specimens prepared and tested at the Material Laboratory.

In the opinion of the authors, evidence is presented which indicates definite superiority of the keyhole notch over the V notch for the class of steel investigated, with respect to reproducibility of the notch contour, reproducibility of the Charpy energy values, and revelation of the transition (scatter) zone in the temperature-impact relationship.

ONE of the primary objectives of a current investigation assigned to the authors, involving medium steel hull plate of welding quality, is to determine the susceptibility of this class of material to embrittlement at subatmospheric temperatures on the basis of single-blow Charpy notched-bar tests.

Preliminary tests indicated that it would be necessary to give detailed consideration to the relative characteristics of the two kinds of notches commonly employed in the Charpy test specimen, the conventional types of which are shown in Figs. 1 and 2. It will be observed that the standard Charpy specimen (Fig. 1) is prepared with a keyhole notch 2 mm. in diameter extending to half the depth of the bar, while the alternate Charpy specimen (Fig. 2) has a 45-deg. V notch extending to 20 per cent of the depth of the bar with a 0.25-mm. radius at the root. The former specimen is generally notched by first carefully drilling with a No. 47 drill and then cutting the slot by any convenient method, while the latter is usually notched with a specially formed milling cutter.

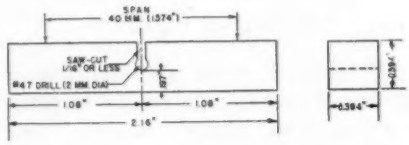


Fig. 1.—Charpy Specimen with Keyhole Notch.

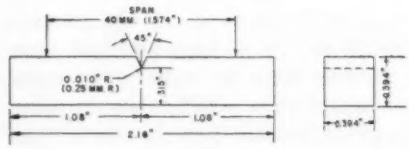


Fig. 2.—Charpy Specimen with V Notch.

While the standard keyhole-notch Charpy specimen was mainly used in the early investigations of low-temperature properties, a number of laboratories have in recent years shifted to the use of the V-notch bar. The proponents of the V-notch bar claim that it shows greater selectivity in revealing the transition temperature and that the energy drop in the transition region is more pronounced because of the greater difference in energy levels above and below the transition temperature. On the other hand, those who have continued the use of the keyhole notch claim that it can be more accurately prepared and consistently reproduced and that the energy values show less "scatter" at temperatures outside the transition zone. It has been further stated that milling cutters for the V notch are difficult to manufacture and reproduce, that slight variations in the V-notch profile appreciably affect the energy values, and that the machining marks or scratches are not in the optimum direction with respect to the breaking stresses. It is the practice of at least one laboratory to alleviate the effect of machining marks by polishing the base of the V notch with a rotating 0.020-in. diameter wire using 600 carborundum abrasive. However, another laboratory has indicated that there appears to be no significant difference between polished and unpolished specimens.

In order to establish the relative merits of the keyhole and V-notches associated with the Charpy test, the authors solicited the cooperation of the following seven laboratories in the preparation of test specimens and in the performance of a series of cross-checking tests:

Battelle Memorial Institute, Columbus, Ohio
Research Laboratory, U. S. Steel Corporation, Kearny, N. J.
Metals Research Laboratory, Carnegie Institute of Technology, Pittsburgh, Pa.
National Bureau of Standards, Washington, D. C.
Watertown Arsenal, Watertown, Mass.
U. S. Naval Engineering Experiment Station, Annapolis, Md.
Naval Research Laboratory, Washington, D. C.

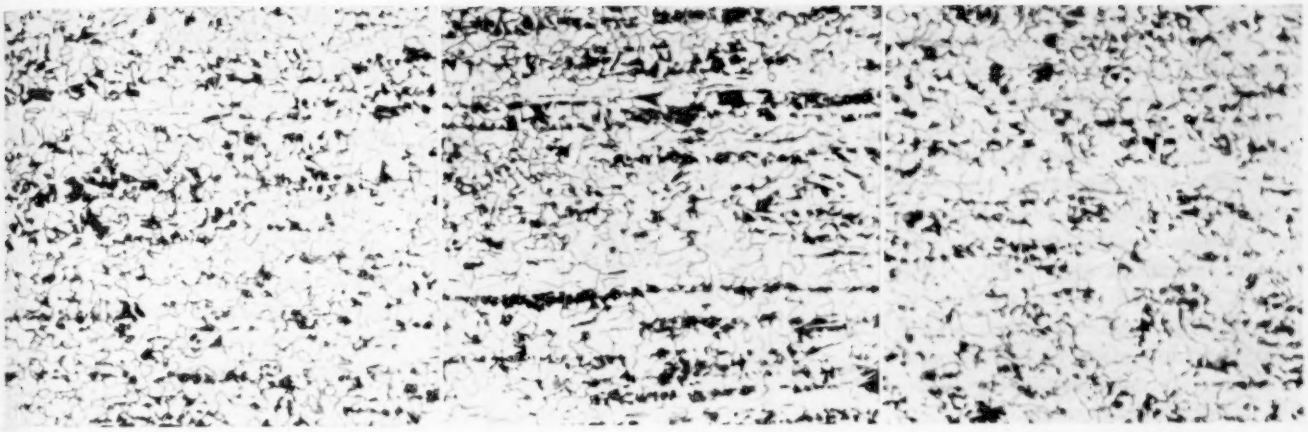
The order in which the laboratories

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] The opinions or assertions contained herein are the private ones of the authors and are not to be construed as reflecting the views of the Navy Department or the Naval Service at large.

[2] Principal Metallurgist and Senior Metallurgist, respectively, Material Laboratory, New York Naval Shipyard, Brooklyn, N. Y.

[3] The boldface numbers in parentheses refer to the references appended to this paper.



Bar 1 Bar 2 Bar 3

Fig. 3.—Microstructures of ½-in. Square Grade Bw Steel Bars (× 100). Longitudinal sections in the annealed condition. Etched in Nital and Picral.

are listed bears no relationship to the order in which the results of tests have been tabulated herein.

The object of the investigation described in this paper was to obtain data which would serve to indicate the reproducibility of the single-blow Charpy notched - bar test, with particular emphasis on variations in energy values for each type of notch as they may be affected by differences in machining of the notch and differences in testing machines.

Material

Several lengths of a low-carbon, semikilled steel in the form of ½-in. square, hot-rolled bar stock were selected for test. The chemical composition of the bars, which were all from the same heat, is given in Table I. Bars 1 and 2 were used for the cooperative tests and bar 3 for the low-temperature work. Charpy specimen blanks cut from these bars were partially annealed by heating for 1 hr. at 1450 F. (furnace-cooled), principally for the purpose of relieving rolling stresses. The microstructures of longitudinal sections of the three bars are shown in Fig. 3. It is to be observed that bar 3, which was used for the low-temperature tests, shows a slightly banded structure that might have been eradicated had a higher annealing temperature been employed.

TABLE I.—CHEMICAL COMPOSITION, PER CENT, OF ½-IN. SQUARE BAR STOCK, GRADE BW STEEL, NAVY DEPT. SPECIFICATION 46-S-4

Element	Bar No. 1[a]	Bar No. 2[a]	Bar No. 3[b]
Carbon	0.22	0.22	0.23
Manganese	0.51	0.52	0.51
Phosphorus	0.015	0.015	0.015
Sulfur	0.040	0.040	0.040
Silicon	0.17	0.17	0.17
Nickel	0.03	0.03	0.04
Chromium	0.02	0.02	0.02
Molybdenum	0.02	0.02	0.01
Vanadium	0.00	0.00	0.01

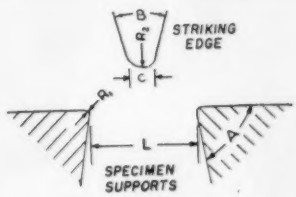
[a] Bars 1 and 2 represent material furnished to the cooperating laboratories.
[b] Bar 3 was used for determination of low-temperature impact properties.

Test Methods

Twenty-four Charpy specimen blanks, completely machined ex-

TABLE II.—DETAILS OF TEST EQUIPMENT AND METHODS USED BY THE COOPERATING LABORATORIES.

Laboratory	Testing Machine: Make	Testing Machine: Capacity, ft-lb.	Striking Velocity, ft. per sec.	Test Temperature, deg. Fahr.	Sizes (see cut below): A, deg.	L, mm.	R_1, mm.	B, deg.	R_2, mm.	C, mm.	Remarks
A	Not stated	264	17	72							[b]
B	Riehle	110–220	12.75	70							[c]
C	Amsler	220	17.4	70	87	40	2.36	30	3.18	3.63	
D	American-made, Sauveur and Boylston	225	15.7	[a]	90	40	0.79	22	1.6	3.2	[d]
E	Riehle P-16	220	Not stated	70	80	40	1.19	30	1.98	3.18	
H	Amsler	120	16.5	70	85	40	1	35	8	4	[b]
J	Riehle	220	Not stated	77		40	2		2		
K	Amsler	210	Not stated	70	85	40	1.27	30	8	4	[e]
	A.S.T.M. requirements				80 (approx.)	40	1	30 (approx.)	8	4	



[a] Not stated: Assumed to be 70 F. as requested by the authors.
[b] Machine complies with general requirements of Tentative Methods of Impact Testing of Metallic Materials (E 23 – 41 T), 1942 Book of A.S.T.M. Standard Part I, p. 1563.
[c] V notches polished with rotating wire using 600 carborundum; 110 ft.-lb. range of machine was used.
[d] V notches formed in shaper.
[e] V notches milled with angle cutter. Experiments conducted by Lab. K on polishing of radius at root of V notch indicate no significant effect in reducing "scatter" between duplicate test bars. It is therefore their standard practice to test with notches in the as-machined condition.

cept for notching, were submitted to each of the cooperating laboratories with instructions to machine twelve with the standard keyhole notch and twelve with the alternate V notch. The laboratories were requested to return six of each type to the authors at the Material Laboratory for test in a 120 ft-lb. Amsler impact testing machine, the results of which were expected to indicate variations in notch preparation within a given laboratory and from one laboratory to the next. The laboratories were also requested to test the balance of the specimens in their own machines, the results of which were expected to indicate variations due to the combined effect of differences in notch preparation and testing machines. The authors also notched and tested six specimens of each type for comparison with the results of the other laboratories. All tests were to be made at room temperature (70 F.).

Each laboratory was assigned a code letter which was used to identify the specimens processed by a particular laboratory and the results of tests thereon. The following example will serve to explain the identification symbols:

(*a*) Specimens AW1 to AW6, inclusive —keyhole notched and tested by laboratory "A."

(*b*) Specimens AX1 to AX6, inclusive—keyhole notched by laboratory "A" and tested by the authors.

(*c*) Specimens AY1 to AY6, inclusive —V notched and tested by laboratory "A."

(*d*) Specimens AZ1 to AZ6, inclusive—V notched by laboratory "A" and tested by the authors.

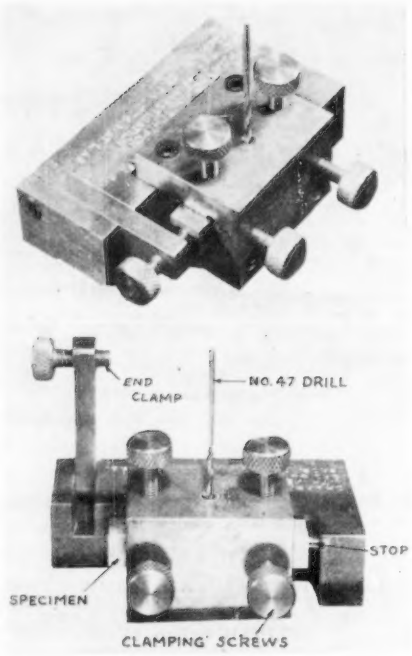
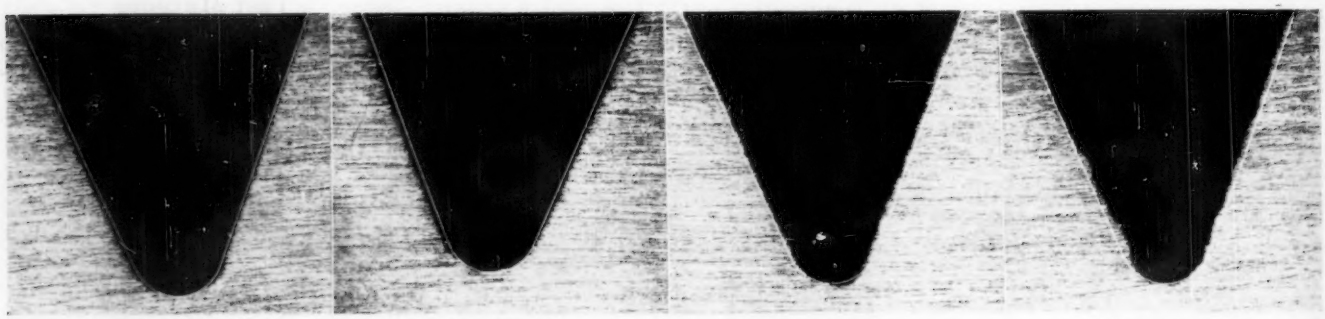


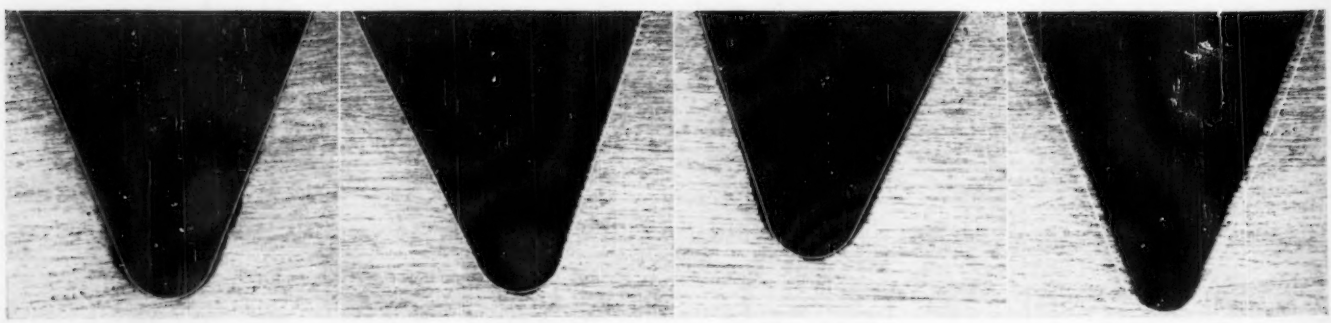
Fig. 4—Drill Jig Used by Authors for Preparation of Keyhole-Notch Charpy Specimens.

The sextuplicate blanks for a particular laboratory were taken from staggered positions in two bars in order to have the individual specimens of all laboratories adjacent to one another. In addition, the blanks from each bar were marked to insure that the notches would all be cut into the same side of the bar stock.

A summary of partial information supplied by the various cooperators with respect to test methods and equipment is given in Table II. It is to be noted that the testing temperature in two instances deviated somewhat from the specified value of 70 F. While the information supplied by the cooperators is not complete, it would appear that there are significant differences in the construction of pendulum-type impact testing machines, particularly in regard to the shape and dimensions of the specimen supports and striking edge, which are not in all cases in full conformity with current A.S.T.M. standards. This was found to be the case with the Amsler machine used by the authors, and, accordingly, new specimen



Laboratory A | Laboratory C | Laboratory E | Laboratory J



Laboratory B | Laboratory D | Laboratory H | Laboratory K

Fig. 5.—V-Notch Profiles of Charpy Specimens Prepared by the Cooper. ng Laboratories (X 50).

Reduce ½ in. reproduction

TABLE III.—RESULTS OF CHARPY IMPACT TESTS ON SPECIMENS NOTCHED BY THE COOPERATING LABORATORIES AND TESTED BY THE AUTHORS AT THE MATERIAL LABORATORY OF THE NEW YORK NAVAL SHIPYARD.

½-in. square grade Bw steel, annealed at 1450 F. (1 hr.). All tests conducted at 70 F. in a 120 ft. lb. Amsler Impact Testing Machine under a striking velocity of 16.5 ft. per second.

	Laboratory	A	B	C	D	E	H	J	K
V-Notch	Z1	35.0	40.3	34.5	29.9	31.8	49.2	26.2	20.8
	Z2	42.3	34.0	45.0	30.5	29.2	46.1	27.0	20.4
	Z3	38.7	35.8	32.5	...	21.4	42.7	21.9	17.5
	Z4	47.0	41.8	34.0	30.0	22.3	39.8	22.0	19.3
	Z5	38.7	34.2	33.5	26.0	24.2	37.8	22.8	17.1
	Z6	34.0	29.3	30.5	19.9	22.5	33.0	23.0	18.2
	Average	39.3	35.9	35.0	27.3	25.2	41.4	23.8	18.9
	Spread	34.0 to 47.0	29.3 to 41.8	30.5 to 45.0	19.9 to 30.5	21.4 to 31.8	33.0 to 49.2	21.9 to 27.0	17.1 to 20.8
Keyhole Notch	X1	33.6	36.2	36.0	36.4	31.7	35.6	35.5	34.1
	X2	34.5	36.0	37.5	34.7	33.8	36.0	34.8	37.0
	X3	33.3	35.4	36.5	34.3	34.0	36.5	34.0	33.5
	X4	34.5	35.6	44.5	36.4	34.7	36.7	37.5	36.9
	X5	33.8	...	38.5	36.2	35.2	36.5	32.0	37.2
	X6	36.0	37.1	40.0	35.9	33.0	35.5	32.5	34.0
	Average	34.3	36.1	38.8	35.7	33.7	36.1	34.4	35.5
	Spread	33.3 to 36.0	35.4 to 37.1	36.0 to 44.5	34.3 to 36.4	31.7 to 35.2	35.5 to 36.7	32.0 to 37.5	33.5 to 37.0

supports and a striking edge were manufactured to conform essentially to A.S.T.M. requirements and substituted for the original parts before proceeding with any tests. It is to be noted that the radius specified by A.S.T.M. for the edge of the specimen supports R_1 is ratner sharp and it was subsequently observed that considerable digging-in occurred at the points of support on specimens requiring relatively high energy values to rupture. This is not considered desirable, since it may appreciably affect the energy values obtained.

Several views of the drill jig used by the authors to prepare their keyhole-notch Charpy specimens are shown in Fig. 4. A jig of this type serves to minimize drifting of the drill and provides for a uniform thickness of metal to be fractured. In addition, the introduction of a stop insures that all specimens are drilled at the same longitudinal distance from one end of the specimen, thus providing for greater ease in lining up specimens in the testing machine. The V notches in specimens prepared by the authors were machined with a high-speed tool-steel milling cutter of the shipyard's own manufacture. In this connection, it might be mentioned that some difficulty was experienced in obtaining a satisfactory cutter. Of four cutters that were manufactured, none was found to be acceptable. Upon regrinding all four, one was found to be reasonably satisfactory, and this cutter was employed in the machining of the authors' specimens, with no post-treatment of the notch.

Before the V-notch specimens returned to the authors were tested, the profiles of the notches of several specimens from each laboratory were polished on 000 emery paper and examined under a magnification of 50 diameters. Photomicrographs of representative specimens are shown in Fig. 5, in which the white line superimposed over the actual notch profile represents the theoretically correct notch outline. It should be especially observed, for purpose of later discussion, that the notch profile of specimens prepared by laboratory K is appreciably sharper than the theoretical outline, as well as those of the other laboratories. The profiles of the keyhole notches were not similarly examined in view of the fact that these were all prepared with a standard No. 47 drill, and that small differences at the root of the notch would have relatively little effect, since this notch is not as sharp as the V notch.

All specimens notched by the cooperators and tested by the authors at the Material Laboratory were held in a water bath at 70 F. for a period of ½ hr., then quickly trans-

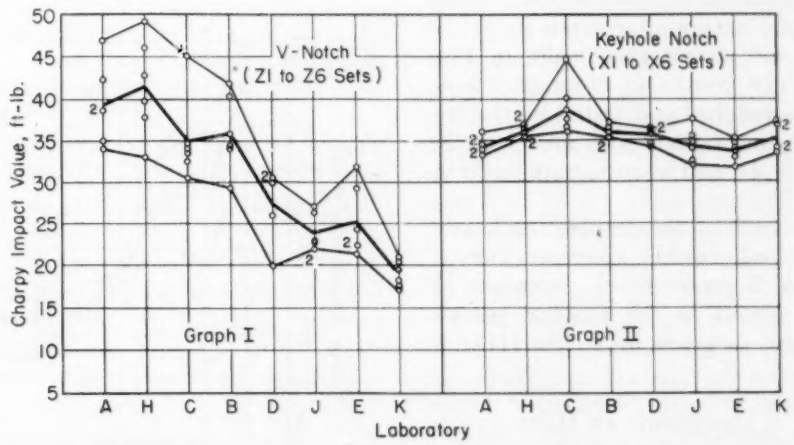


Fig. 6.—Results of Charpy Impact Tests on Specimens Notched by the Cooperating Laboratories and Tested by the Authors.

TABLE IV.—RESULTS OF CHARPY IMPACT TESTS ON SPECIMENS NOTCHED AND TESTED BY THE COOPERATING LABORATORIES.

½-in. square grade Bw steel, annealed at 1450 F.

	Laboratory	A	B	C	D	E	H	J	K
V-Notch	Y1	54.0	31.5	36.0	29.3	30.0	49.2	28.0	15.8
	Y2	59.4	33.5	44.0	30.7	27.0	46.1	24.0	18.7
	Y3	60.2	33.0	43.0	30.7	24.0	42.7	29.0	15.8
	Y4	54.0	31.5	40.0	27.7	27.0	39.8	29.0	15.1
	Y5	59.8	32.0	37.0	33.8	27.0	37.8	22.0	14.2
	Y6	48.0	30.0	47.0	32.4	22.0	33.0	27.5	15.5
	Average	55.9	31.9	41.2	30.8	26.2	41.4	26.6	15.9
	Spread	48.0 to 60.2	30.0 to 33.5	36.0 to 47.0	27.7 to 33.8	22.0 to 30.0	33.0 to 49.2	22.0 to 29.0	14.2 to 18.7
Keyhole Notch	W1	40.0	30.0	33.0	36.8	31.0	35.6	31.0	31.8
	W2	41.8	34.0	32.0	35.2	34.0	36.0	31.5	31.8
	W3	38.2	32.0	33.0	35.2	32.0	36.5	31.0	31.1
	W4	40.0	37.0	36.0	35.8	31.0	36.7	31.0	29.9
	W5	39.4	34.0	33.0	36.8	33.0	36.5	28.5	32.2
	W6	37.2	34.0	31.0	35.2	33.0	35.5	31.0	33.0
	Average	39.4	33.5	33.0	35.8	32.3	36.1	30.7	31.6
	Spread	37.2 to 41.8	30.0 to 37.0	31.0 to 36.0	35.2 to 36.8	31.0 to 34.0	35.5 to 36.7	28.5 to 31.0	29.9 to 33.0

TABLE V.—SUMMARY OF SPREAD IN CHARPY IMPACT TEST RESULTS.
Values given are in ft-lb. Letters in parentheses denote the individual laboratories involved.

	Keyhole Notch		V-Notch	
	Notched by Cooperators and Tested by Authors (X1 to X6)	Notched and Tested by Cooperators (W1 to W6)	Notched by Cooperators and Tested by Authors (Z1 to Z6)	Notched and Tested by Cooperators (Y1 to Y6)
Minimum spread shown by an individual laboratory	35.5–36.7 or 1.2 (H)	35.5–36.7 or 1.2 (H)	17.1–20.8 or 3.7 (K)	30.0–33.5 or 3.5 (B)
Maximum spread shown by an individual laboratory	36.0–44.5 or 8.5 (C)	30.0–37.0 or 7.0 (B)	33.0–49.2 or 16.2 (H)	33.0–49.2 or 16.2 (H)
Over-all spread of individual results—all laboratories	31.7 (B) to 44.5 (C) or 12.8	28.5 (J) to 41.8 (A) or 13.3	17.1 (K) to 49.2 (H) or 32.1	14.2 (K) to 60.2 (A) to 46.0
Spread of averages	34.3 (A) to 38.8 (C) or 4.5	30.7 (J) to 39.4 (A) or 8.7	18.9 (K) to 41.4 (H) or 22.5	15.9 (K) to 55.9 (A) or 40.0
Over-all average	35.6	34.1	30.9	33.7

ferred to the testing machine and ruptured.

Test Data

The results of single-blow Charpy tests on specimens notched by the cooperating laboratories and tested by the authors are given in Table III and shown graphically in Fig. 6. The results of tests on specimens notched and tested by the cooperating laboratories are given in Table IV and shown graphically in Fig. 7.

In each of the graphs, the heavy line represents average values. Table V represents a summary of the spread in the Charpy energy values, as given in Tables III and IV.

Discussion of Data

In the selection of the material and in its subsequent preparation for cross-checking purposes, as well as in the conduct of the test, every effort was made to eliminate:

(*a*) Variables due to material composition (material used was relatively free from segregation and all bars were from the same heat and of the same analysis).

(*b*) Variables due to material condition (all bars were hot-rolled in the same lot and given a stress-relieving heat treatment (annealed)).

(*c*) Variables due to material size and orientation of notch (all test specimens were machined from ½-in. square stock and the notches were cut into the same face throughout).

(*d*) Variables due to temperature of test (cooperating laboratories were requested to perform the Charpy tests at room temperature (70 F.). It may be noted from Table II that at least two of the cooperating laboratories deviated somewhat from this requirement.)

Transition Zone Determination:

Referring to Figs. 6 and 7 and Table V, it would appear that the keyhole notch afforded better reproducibility within individual laboratories, as well as from one laboratory to another. However, it was suspected that not all of the "scatter" in the V-notch test results was due to lack of reproducibility in the notch itself or to variations in testing machines or methods. At least part of the "scatter" was believed to be due to an inherent characteristic of the material selected for test which, at a temperature of 70 F., was more evident in the case of the V notch than in the case of the keyhole notch. An explanation for the greater "scatter" in V-notch test results was therefore sought in the temperature-impact relationship of the material. In this regard, attention is invited to the statement of McAdam and Clyne (1)[3] based on the work done by Greaves and Jones (2), that "the sharper the notch, the higher is the temperature of the drop," referring to the effect of the notch on the temperature of transition from fibrous to granular fracture.

Specimens were accordingly prepared from bar 3 for random coverage of the temperature range from

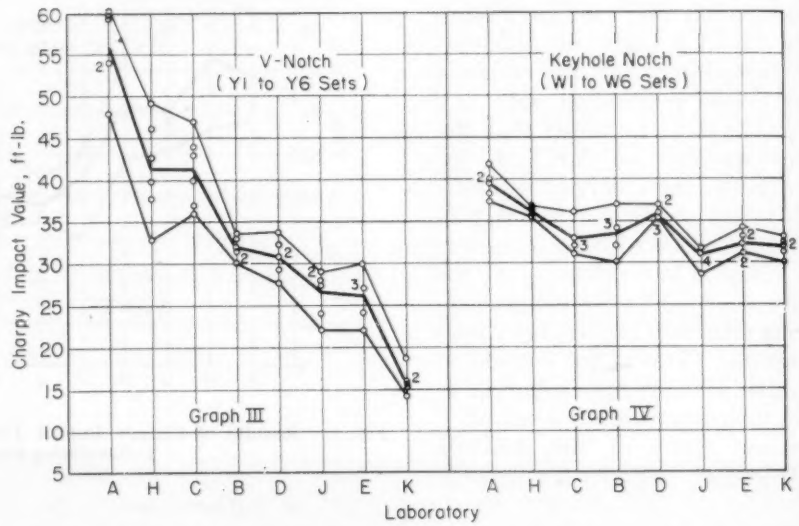


Fig. 7.—Results of Charpy Impact Tests of Specimens Notched and Tested by the Cooperating Laboratories.

TABLE VI.—EFFECT OF LOW TEMPERATURES ON CHARPY IMPACT VALUES.
Specimens notched and tested by the authors. ½-in. square grade Bw steel, annealed at 1450 F. (1 hr.).

	Test Temperature	120	100	90	80	70	60	50	40	30	20	10	0	−20
V Notch	1	78.5	61.3	54.5	51.0	32.0	24.8		16.5		8.3		5.5	
	2	90.0	61.5	51.5	61.0	50.0	38.5		16.0		8.8		5.3	
	3	83.0	51.8	53.0	31.5	40.0	23.0		19.0		10.8		5.5	
	4	85.0	60.8	53.5	49.0	30.8	35.0		20.0		8.5		4.5	
	5	77.3	82.0	51.0	47.0	43.0	19.0		18.0		8.0		5.5	
	Average	82.8	63.5	52.7	47.9	39.2	28.1		17.9		8.9		5.3	
	Spread	77.3 to 90.0	51.8 to 82.0	51.0 to 54.5	31.5 to 61.0	30.8 to 50.0	19.0 to 38.5		16.0 to 20.0		8.0 to 10.8		4.5 to 5.5	
Keyhole Notch	1				37.0		34.0	31.5	31.5	30.0	30.5	5.3	24.8	2.5
	2				38.0		37.5	34.5	34.0	29.3	7.0	4.8	4.0	3.0
	3				39.5		36.5	32.8	29.5	8.0	30.5	5.0	22.3	3.0
	4				36.0		35.3	32.3	31.6	28.0	6.5	4.5	4.0	2.8
	5				42.5		33.5	32.8	12.5	29.8	28.3	5.0	4.8	3.0
	Average				38.6		35.4	32.8	27.8	25.0	20.6	4.9	12.0	2.9
	Spread				36.0 to 42.5		33.5 to 37.5	31.5 to 34.5	12.5 to 34.0	8.0 to 30.0	6.5 to 30.5	4.5 to 5.3	4.0 to 24.8	2.5 to 3.0

[3] The boldface numbers in parentheses refer to the references appended to this paper.

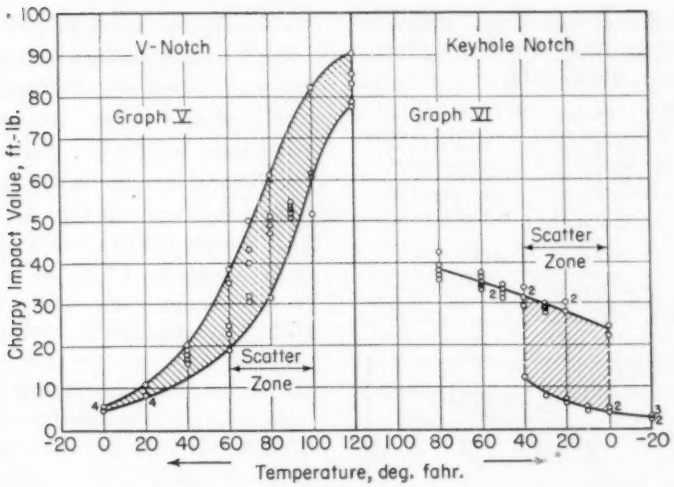


Fig. 8.—Results of Low-Temperature Charpy Impact Tests on Specimens Notched and Tested by the Authors.
½-in. square grade Bw steel, annealed 1 hr. at 1450 F.

+120 to −20 F. for the purpose of determining the temperature-impact relationship of the material, as affected by the keyhole and V types of notches. The test specimens were machined, notched, and tested at the Material Laboratory by the authors. Specimens were prepared in quintuplicate for test at each temperature and for each type of notch. Specimens were maintained at an intended temperature in a liquid bath (water for temperatures of 70 F. and above, and acetone and dry ice for temperatures below 70 F.) for a period of at least 20 min., and then quickly transferred to the testing machine and ruptured.

Results of the temperature-impact series are given in Table VI and shown graphically in Fig. 8. The appearance of the fractures is shown in Fig. 9, in which the orientation of the specimens is identical with the arrangement of the test data in Table VI.

It is to be observed from Fig. 9 that a suggestion of the onset of an almost completely brittle type (granular) fracture occurred at a temperature of 100 F. in the V notch (middle specimen in set), and at a temperature of 40 F. in the case of the keyhole notch (bottom specimen in set). In both instances, these temperatures mark the beginning of "scatter" in the absorbed energy values. This may also be confirmed by reference to Table VI and Fig. 8.

Figure 9 also indicates that the transition zone is complete at a temperature below 60 F. for the V notch, and at a temperature below 0 F. for the keyhole notch, as evidenced by the fact that all specimens tested below these temperatures exhibit a completely granular fracture. In both cases, these temperatures mark the end of "scatter" in the absorbed energy values, as indicated in Table VI and shown graphically in Fig. 8.

It would therefore be expected that keyhole-notch Charpy specimens of the material selected and tested at 70 F., which is above the transition zone, should show relatively little "scatter" in the results and an energy-absorption level, on the basis of graph V (Fig. 8), in the vicinity of 36 ft-lb. It will be noted that the over-all average value obtained on specimens notched by the cooperators and

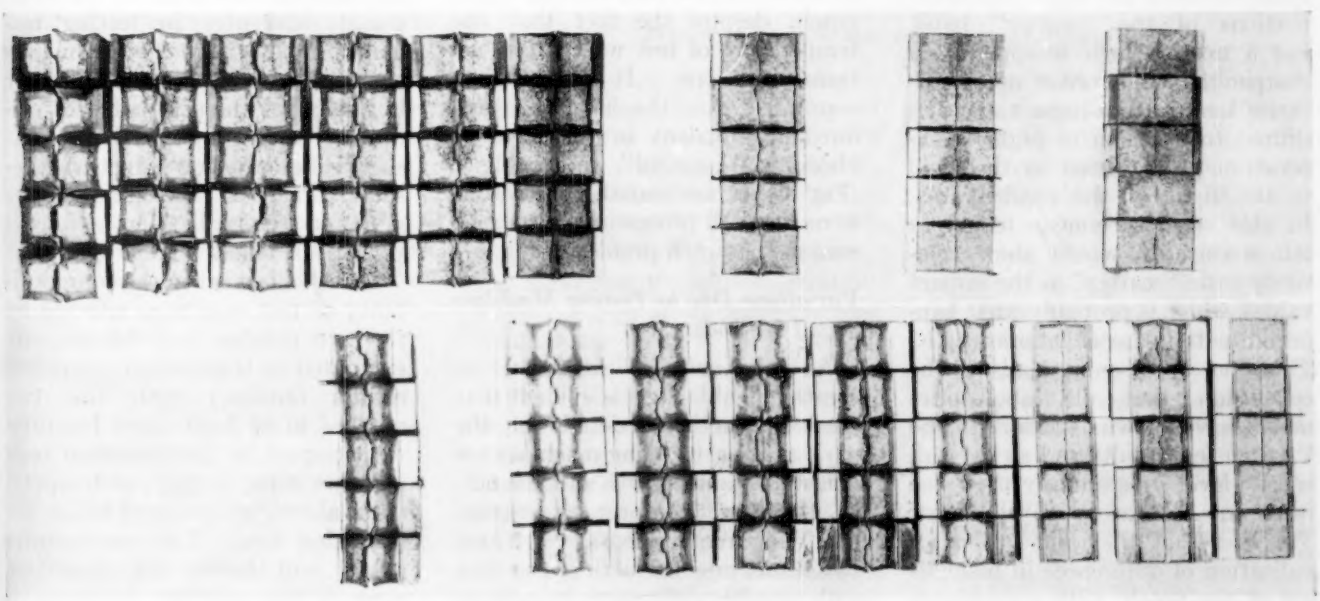


Fig. 9.—Fractures of Low-Temperature Charpy Impact Specimens

½-in. square grade Bw steel, annealed a, 1450 F., 1 hr.

tested by the authors is 35.6 ft-lb. Graph II (Fig. 6) indicates that the energy absorption level is practically the same for all cooperators, particularly if the one isolated value of cooperator C be disregarded; this is indicative of good keyhole-notch reproducibility.

It would also be expected that V-notch Charpy specimens of the material selected and tested at 70 F., which is within the transition zone, *should* show "scatter" in the results of tests. The low level and relative lack of "scatter" in the values obtained on V-notch Charpy specimens notched by several of the cooperators (graph I, Fig. 6) may be a reflection of the fact that the root radii of the notches prepared by these laboratories are less than the theoretically correct radius which, at least in the case of laboratory K, was sharp enough to have shifted the transition zone or region of "scatter" to a temperature above 70 F. This factor may be explained further by reference to Fig. 10. The shaded band is intended to represent the temperature-impact relationship for the theoretically correct V-notch profile. If specimens having the correct notch are tested at temperature *T*, for example, the impact values would be expected to show "scatter" to an extent indicated by the vertical height between the upper and lower portions of the "scatter" band. For a notch which is appreciably sharper than the correct notch, the entire temperature-impact curve is shifted to a region of higher temperature, as indicated by the band to the right of the shaded area. In this case, specimens tested at temperature *T* would show relatively little "scatter" in the impact values, which is probably what happened in the case of laboratory K. This line of reasoning leads to the conclusion that all laboratories *should* have shown "scatter" in the V-notch test results and an over-all energy level substantially the same from one laboratory to the next. The fact that they did not is an indication of differences in machining of the notch, with correspondingly poor reproducibility. In further support of this concept, the results of tests made on two sets of specimens of the subject material, V-notched and tested on different occasions at 70 F. by the authors, are given in Table VII.

TABLE VII.

	49.2 ft-lb. 46.1 ft-lb. 42.7 ft-lb. 39.8 ft-lb. 37.8 ft-lb. 33.0 ft-lb.	32.0 ft-lb. 50.0 ft-lb. 40.0 ft-lb. 30.8 ft-lb. 43.0 ft-lb.
Average	41.4 ft-lb.	39.2 ft-lb.
Spread	33.0 to 49.2	30.8 to 50.0

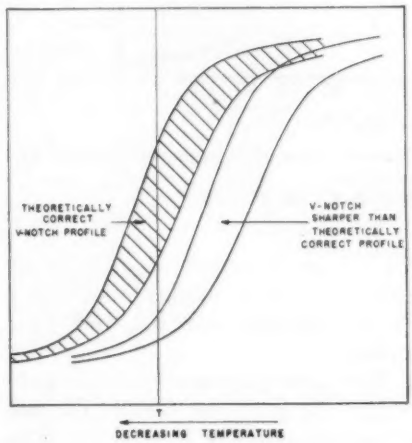


Fig. 10.—Effect of Increasing Sharpness of V Notch on the Location of the Transition Temperature Zone.

These values show approximately the same vertical "scatter" attributed to transition zone influences, and also practically the same over-all spread, which is indicative of reproducibility in machining of the notch, despite the fact that the temperature of test was within the transition zone. It is therefore concluded that the lack of reproducibility evident in the form of "horizontal spread" in graph I (Fig. 6) is associated with variations in notch processing, as may be seen in the notch profiles of Fig. 5.

Variations Due to Testing Machines and Methods:

As previously indicated, and as shown in Table II, it is evident that the constructional details of the various impact testing machines are not well standardized and do not, in all cases, conform to current A.S.T.M. requirements. These variations in construction, together with possible differences in calibration and test methods, may account for the additional discrepancies between the results of tests made on specimens notched and tested by the cooperators, as compared to the results of tests on specimens notched by the cooperators and tested by the authors (compare Figs. 6 and 7). For example, for V-notch specimens prepared and tested by cooperator A, the impact values range from 48.0 to 60.2 ft-lb. (average 55.9), as compared to a range of 34.0 to 47.0 ft-lb. (average 39.3) for specimens notched by cooperator A and tested by the authors; for the keyhole notch, the respective values are 37.2 to 41.8 ft-lb. (average 39.4) and 33.3 to 36.0 ft-lb. (average 34.3). Since the notches were all machined by cooperator A, the appreciable differences between the values obtained by cooperator A and those obtained by the authors must be attributed to variations in the two testing machines or test methods. It has been suggested by one cooperator that the striking velocity, initial energy of the pendulum, variations in the rigidity of the various machines, and dimensional variations in the specimen supports may have had some effect on the test results. The authors are inclined to believe that, of these suggested variations, the effect of variations in the dimensions of the specimen supports and striking edge is perhaps the most significant. An investigation into the constructional differences in testing machines, and their effects on the energy values is, of course, a study in itself, but there is sufficient evidence to indicate qualitatively that such differences do affect the results. There is therefore further need for standardization of impact testing machines.

It is believed that the reproducibility of test results as affected by the two notches may be properly evaluated on the basis of comparing results obtained with the two notches in at least three locations with respect to the transition temperature zone, namely, at temperatures above, within, and below the transition zone. For temperatures above and below the transition zone, a low average deviation is desired, and for temperatures within the transition zone, a high average deviation reveals the transition zone to better advantage. Table VIII

is based upon values given in Table VI, and represents the degree of reproducibility obtainable by the authors.

TABLE VIII.

Transition Zone	V Notch 100 to 60 deg. Fahr.	Keyhole Notch 40 to 0 deg. Fahr.
Test temperature immediately above transition zone	120	50
Spread, ft-lb	77.3 to 90.0	31.5 to 34.5
Average value, ft-lb	82.8	32.8
Average deviation, ft-lb	3.9	0.7
Average deviation, per cent	4.7	2.1
Test temperature immediately below transition zone	40	−20
Spread, ft-lb	16.0 to 20.0	2.5 to 3.0
Average value, ft-lb	17.9	2.9
Average deviation, ft-lb	1.3	0.16
Average deviation, per cent	7.3	5.5
Test temperature in middle of transition zone	80	20
Spread, ft-lb	31.5 to 61.0	6.5 to 30.5
Average value, ft-lb	47.9	20.6
Average deviation, ft-lb	6.9	11.0
Average deviation, per cent	14.4	53.4

It is conceded that, if a test temperature of 20 F. had been chosen instead of 70 F., the results with the keyhole notch would have shown a greater spread than that encountered with the V notch at 20 F. However, it is believed that the differences in energy level from one laboratory to another, as found with the V notch at 70 F., would not be evident with the keyhole notch at 20 F., since the keyhole notch was found to have a higher order of reproducibility than the V notch. In this connection, it is to be noted that a jig-guided drilled hole can be reproduced more accurately using different No. 47 drills, than can a V-notch using different milling cutters.

It is evident from Fig. 8 that the transition or "scatter" zone is more sharply defined by the keyhole-notch specimen than by the V-notch specimen. The characteristic temperature-impact relationship shown in Fig. 11 is similar to that which was actually obtained on the low-carbon, semikilled steel with the keyhole notch (Fig. 8).

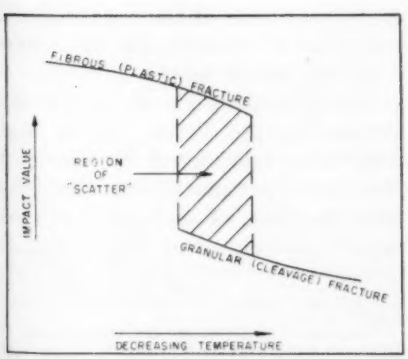


Fig. 11.—Characteristic Temperature-Impact Relationship.

At temperatures above the region of "scatter," the energy values are high, and the fractures are of the plastic or fibrous type. At temperatures below the region of "scatter," the energy values are low and the fractures are of the granular or cleavage type. In the region of "scatter," the energy values tend to be either concordantly high with fibrous fractures, or concordantly low with granular fractures. It is believed that Fig. 12, representing temperature-impact relationships for two 20-lb. medium steel hull plate samples, will further demonstrate the greater selectivity of the keyhole notch in locating the region of scatter, and in revealing differences in the susceptibility of the materials to low-temperature embrittlement. It is to be observed that, on the basis of the V-notch, the temperature-impact curves for the two steels may practically be superimposed, and there is little to indicate any difference in the behavior of these two steels with decreasing temperature. On the other hand, the graphs based on the keyhole notch indicate a marked difference with decreasing temperature, namely, steel marked CW1 shows the onset of the transition range at −10 F., as compared with +70 F. for steel JX2. The manner in which Fig. 12 reveals the onset and completion of the scatter range is quite evident, inasmuch as the V-notch curves show a gradual decrease in energy values with no abrupt change to mark the transition from fibrous to cleavage-type fracture, while the keyhole-notch curves sharply reveal the transition zone in the manner illustrated by the characteristic temperature-impact curve shown in Fig. 11.

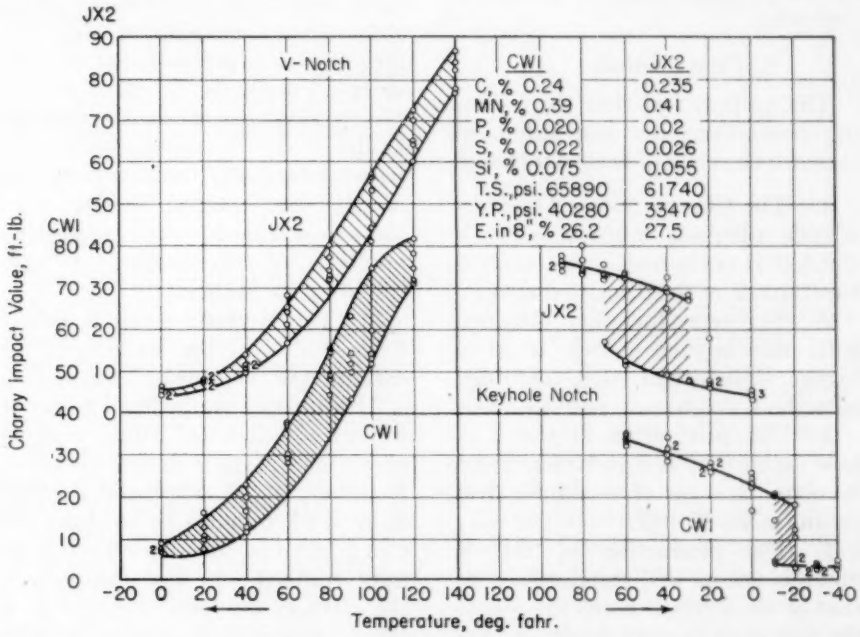


Fig. 12.—Low-Temperature Charpy Notched Bar Impact Properties of Two Medium Steel Hull Plates.
20-lb. medium steel hull plate, as-rolled, longitudinal.

The authors believe that the following comments, taken from an unpublished report prepared by M. Gensamer and co-workers, are of pertinent interest:

(*a*) Temperature-energy absorption curves were determined for a number of rimmed, semikilled and killed steels in the as-rolled and normalized conditions, using both keyhole and V-notch specimens in the Charpy impact test.

(*b*) A single curve does not adequately represent the behavior of a given steel in its transition range, since the mechanism of fracture is changing, and the region is by nature one of great scatter.

(*c*) With V-notch specimens, the separation between the various steels is not as well defined as in the case of the keyhole

notch specimens, and the order of drop-off is somewhat different.

(*d*) In every instance, the keyhole notch specimens indicated a lower transition temperature than observed with the V-notch specimens, the magnitude of the difference depending on the particular steel examined.

(*e*) The keyhole notch produced a greater selectivity in the separation of the transition ranges of the various steels, and from this point, it is to be regarded as superior to the V-notch test for this group of steels. It should be emphasized, however, that the orders of merit of the various steels indicated by the two tests differ.

Conclusions

The authors feel that the following conclusions are warranted, at least for the class of material tested:

1. The Charpy notched-bar test affords adequate reproducibility if the test is performed at a temperature outside of the transition zone.
2. The reproducibility obtained with the keyhole notch is of a higher order than that obtained with the V notch.
3. The production of the keyhole notch is well standardized and involves the use of a simple drill jig and a No. 47 drill.
4. The production of the V notch is not as well standardized as that of the keyhole notch in view of the fact that various forms of cutters and occasional post-treatment of the root radius are employed, resulting in appreciable variations in notch profile.
5. The variations encountered with the V notch were sufficient to cause appreciable differences in the energy-absorption level.
6. The variations encountered in the V-notch profiles were sufficient to cause a shift in the transition zone of the material tested. The sharper the notch, as in the case of cooperator K, the higher is the transition temperature zone.
7. The variations in the construction of impact testing machines or test methods resulted in appreciable differences in the Charpy keyhole- and V-notch test values, based principally upon comparison of the cooperators' results with those obtained on specimens notched by the cooperators and tested by the authors.
8. The keyhole notch is better than the V notch in respect to definition of the zone of "scatter."

The authors are inclined to favor wider adoption of the keyhole notch for Charpy notched-bar tests. However, it is appreciated that more work remains to be done before a trend in this direction can be fully realized. In this connection, the authors are now engaged in a rather extensive program of tests to determine the effect of variations in the geometry of the V and keyhole types of notch on the energy level and location of the transition zone in a variety of steels in various conditions. Since the results of this work will not be available for quite some time, the authors considered it desirable to publish their findings to date in order to stimulate discussion and further development in this field.

Acknowledgment:

The authors wish to acknowledge the cooperation of each of the laboratories who participated in this work and the assistance received from members of the Material Laboratory of the New York Naval Shipyard. The authors also wish to express their appreciation to the Bureau of Ships, Navy Department, for permission to publish this paper.

References

(1) D. J. McAdam, Jr., and R. W. Clyne, "The Theory of Impact Testing: Influence of Temperature, Velocity of Deformation, and Form and Size of Specimen on Work of Deformation," *Proceedings*, Am. Soc. Testing Mats., Vol. 38, p. 119 (1938).

(2) R. H. Greaves and J. A. Jones, "The Effect of Temperature on the Behavior of Iron and Steel in the Notched-Bar Impact Test," *Journal*, Iron and Steel Inst. Vol. 102, No. 2, p. 123(1925).

Determining Consistency on Small Samples of Lubricating Grease[1]

By R. F. McKibben[2]

Synopsis

A Disk Viscometer and method for determining apparent viscosity of lubricating greases are described where the sample size is 4.2 mg. The apparent viscosity of greases as determined on the Disk Viscometer is compared with more common characteristics. Operators are able to repeat determinations on a given sample within 14 per cent and to reproduce another's work within 19 per cent.

It has long been recognized that there is a need for a method of determining consistency on small samples of lubricants. There is often occasion to examine used lubricants from bearings where only a small sample is available. There are also many types of lubricant tests where it is highly desirable to determine the consistency of the lubricant following the test, but where the amount of material is so small that none of the conventional methods of determining this characteristic can be used.

The Miniature Penetrometer developed by the Texas Oil Co., and now being considered for use as a standard instrument, has partially filled the need of measuring consis-

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] This paper was presented at a meeting of Technical Committee G of A.S.T.M. Committee D-2 on Petroleum Products and Lubricants, January 17, 1947, in Washington, D. C.

[2] Materials Laboratory, The National Cash Register Co., Dayton, Ohio.

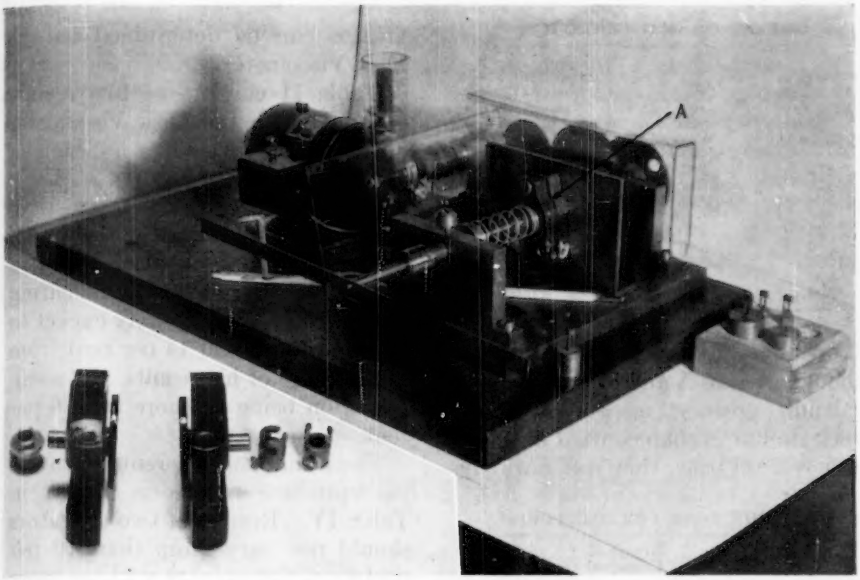


Fig. 1.—Disk Viscometer.

tency on small samples. However, it requires a sample of at least 3 g., which may not always be available, and it is also subject to the complaint that is made against the A.S.T.M. Cone Penetrometer—that is, the results obtained lack practical significance. The Materials Laboratory of The National Cash Register Co. has developed an instrument called a Disk Viscometer which more fully fills this need. This instrument is capable of determining the apparent viscosity of either liquid or plastic materials over a wide range in consistency on samples of only a few milligrams.

The "gumming" characteristics of lubricants are of particular significance to our application. Determination of this characteristic consists of spreading 1.5 ml. of the lubricant in question on the bottom of a 10-cm. Petri dish, exposing it at 158 F. in a forced draft oven, and comparing the consistency before and after exposure. Originally the comparison of consistency was made by "feel." But this was decidedly inadequate since only comparatively large differences could be detected, and there was no quantitative way of reporting results. The sample was so small that no conventional method of measuring consistency could be used. In attempting to find a method of measuring consistency on the sample available the Disk Viscometer was developed.

The instrument (see Fig. 1) consists of two flat disks mounted facing each other in such a manner that when they are pressed together they can align themselves with each other. One disk is driven through a gear chain by a variable speed motor and can be driven at speeds from 2 to 18 rpm. The other disk is attached to an arm calibrated in millimeters on which weights of various sizes may be placed at different positions. A film of lubricant may be distributed between the disks, by placing a sample near the center of the disks and allowing the one to turn against the other while a spring tension is forcing them together. The spring tension is released when the material under test appears at the edge of the disks, eliminating any further spreading or leakage. The film of lubricant distributed over the disks will transmit a torque from the driven disk to the stationary one. This torque is measured by balancing it with weights on the calibrated arm. From the weight of sample used, the torque delivered and the dimensions and speed of the instrument, the apparent viscosity of the material may be computed. For the instrument used in this work, a disk speed of 6 rpm. and a material having a specific gravity of 0.9, the apparent viscosity in Saybolt Universal Seconds is $wt \times 11.33$, where w is the weight of sample in milligrams, and t is the torque in gram centimeters. The derivation of this formula and the details of the method used with the instrument have been reported (**3**).[3]

The validity of the Disk Viscometer and method used are shown in Fig. 2. It is seen that viscosities determined with the instrument agree within 10 per cent with those determined by modified Ostwald viscometers and corrected for temperature on the A.S.T.M. Viscosity-Temperature Chart.

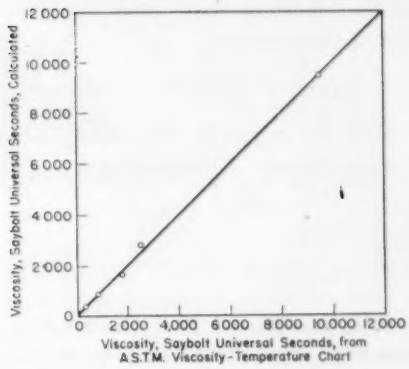


Fig. 2.—Comparison of Viscosities Determined on Disk Viscometer with Those Determined with A.S.T.M. Method.

A quantitative evaluation of apparent viscosity, determined with the Disk Viscometer now replaces "feel" in the "gumming" test mentioned before, and the result is reported as the percentage of increase in viscosity occurring during exposure.

In determining gumming on various lubricants, it was found that the instrument was not limited to use with liquid materials. Accordingly the possibility of using the instrument to measure apparent viscosity on regular shipments of greases and other plastic materials was considered. As a result, determining apparent viscosity on petrolatum and printing inks has been established on a routine basis.

Viscosities ranging from 200 to 500,000 Saybolt Universal Seconds may be measured with the Disk Viscometer. Leakage occurs when working with oils lighter than 200 Saybolt Universal Seconds and difficulty in spreading the sample is experienced when materials with vis-

[3] The boldface numbers in parentheses refer to the references appended to this paper.

TABLE I.—COMPARISON OF LUBRICATING GREASE CHARACTERISTICS.

Material	Soap		Viscosity of Oil Base at 100 F., Saybolt Universal Seconds	Penetration Worked	Apparent Viscosity (Disk Viscometer), Saybolt Universal Seconds
	Metal	Per cent			
Grease A	Sodium	15	270	287	4 045
Grease B	Sodium	13	454	322	5 446
Grease H	Sodium	..	300	33 (Unworked)	28 583
Grease D	Aluminum	4	55	380+	404
Grease C	Aluminum	4	150	380	892
Grease E	Aluminum	4	1100	380	2 152
Grease F	Calcium	8	300	349	4 750
Grease G	Calcium	16	300	283	9 094

cosities above 500,000 Saybolt Universal Seconds are used. This is a wider range in consistency than may be determined with any conventional viscometer.

TABLE II.—APPARENT VISCOSITY DATA WITH THE DISK VISCOMETER.

Determination	Grease A, Saybolt Universal Seconds		Grease C, Saybolt Universal Seconds	
	Operator No. 1	Operator No. 2	Operator No. 1	Operator No. 2
No. 1	4100	4375	918	843
No. 2	3910	4375	922	825
No. 3	3930	4350	926	843
No. 4	3990	4275	936	843
No. 5	3280	3978	982	887

It is recognized that the rate of shear is a significant factor in determining apparent viscosity on plastic materials. Accordingly the sample size is held constant for any given type of material where rate of shear is considered significant.

The main purpose of this paper is to illustrate the use of this instrument in determining consistency, that is, apparent viscosity, of lubricating greases, particularly where only a small sample is available, and to compare the results with those of more conventional tests.

In the work presented, a sample size of 4.2±0.2 mg. was used with a standard disk speed of 6 rpm. so that a uniform rate of shear pattern was used throughout. All determinations were made at 80±2 F.

In comparing the characteristics of lubricating greases, Table I, it is seen that the apparent viscosity as determined by the Disk Viscometer cannot be correlated with any one of the more common characteristics. However, there is correlation with different factors; for instance, with greases A and B, and C, D, and E there is a relation between apparent viscosity and the viscosity of the oil base, but this does not hold with greases F, G, and H. However, with greases F and G there is a close correlation among soap content, penetration, and apparent viscosity, while greases A, B, C, D, and E show none. It is also noted that although greases A and G, sodium and calcium greases, respectively, are very similar in soap content and viscosity of oil base, they differ widely in apparent viscosity as determined with the Disk Viscometer. This comparison indicates that the consistency, that is, apparent viscosity, of a grease is a function of soap, soap content, and viscosity of oil base, as has been pointed out by Beerbower, Sproule, Patberg, and Zimmer (1).

Georgi and O'Connell (2) have pointed out that viscosity is a fundamental property of greases just as it is of lubricating oils. It is also of much greater practical significance than other common characteristics of greases. In Table I it is seen that greases D and E have practically the same penetration but it would be a serious error to use grease E for an application that should have grease D, or *vice versa*. The difference in the nature of these greases is readily apparent from the apparent viscosity determined on the Disk Viscometer.

Grease H was included to show that the consistency of very heavy greases can be determined on the Disk Viscometer.

Table II consists of five results obtained with the Disk Viscometer on each of two greases by each of two operators.

Tables III and IV consist of analyses of the data in Table II. The data obtained by each operator are analyzed in Table III indicating that a single operator may expect to vary no more than 14 per cent from the average of his results, the mean deviation being no more than 6 per cent.

The ability of different operators to reproduce results is shown in Table IV. Results of two operators should not vary more than 19 per cent from the average with no more than 6 per cent mean deviation from the average.

It is quite probable with more work and acquaintance with measuring grease consistency that these variations could be reduced considerably.

Conclusions

1. The apparent viscosity of lubricating greases may be determined with the Disk Viscometer on samples as small as 4 mg.

2. The apparent viscosity of lubricating greases as determined with the Disk Viscometer is of greater practical significance than any one of the conventional characteristics.

TABLE III.—DISK VISCOMETER REPEATABILITY.

	Grease A, Saybolt Universal Seconds		Grease C, Saybolt Universal Seconds	
	Operator No. 1	Operator No. 2	Operator No. 1	Operator No. 2
Apparent viscosity (average of five determinations)	3820	4271	937	848
Maximum deviation from average	540 (14.1%)	293 (6.9%)	45 (4.8%)	39 (4.6%)
Mean deviation from average	238 (6.2%)	117 (2.7%)	22.2 (2.4%)	15.4 (1.8%)

TABLE IV.—DISK VISCOMETER REPRODUCIBILITY.
(Two Operators)

	Grease A, Saybolt Universal Seconds	Grease C, Saybolt Universal Seconds
Apparent viscosity (average of ten determinations—5 of each operator)	4045	892
Maximum deviation from average	765 (19%)	90 (10%)
Mean deviation from average	238.7 (5.9%)	44.3 (5.0%)

3. Viscosities ranging from 200 to 500,000 Saybolt Universal Seconds may be determined with the Disk Viscometer.

4. When working with plastic materials conditions are controlled so that a constant rate of shear pattern is used for each type of material.

Acknowledgments:

The author gratefully acknowledges the interest and support of this work shown by Messrs. B. C. Morris, L. J. Hibbert, and C. F. Cowen of the Materials Laboratory of the National Cash Register Co.

REFERENCES

(1) A. Beerbower, L. W. Sproule, J. B. Patberg, and J. C. Zimmer, "Flow Characteristics of Lubricating Greases," *Institute Spokesman*, Vol. 6, November, December, 1942, and January, February, 1943.

(2) C. W. Georgi and John F. O'Connell, "The Effect of Mineral Oil Pour Point on the Flow Characteristics of Lubricating Greases," *Institute Spokesman*, Vol. 8, December, 1944.

(3) R. F. McKibben, "Disc Viscometer," *Lubrication Engineering*, Vol. 2, No. 1, p. 15, March, 1946.

Report on Correlation of Laboratory and Service Abrasion Tests of Rubber Tire Treads

Prepared by A. E. Juve,[1] J. H. Fielding,[2] and F. L. Graves[3] on behalf of Section of Subcommittee XIV on Abrasion Tests for Rubber, of A.S.T.M. Committee D-11 on Rubber and Rubber-Like Materials

LABORATORY abrasion tests are run for control, development, and research purposes in most rubber laboratories. The question "How well do the results of a particular abrasion test correlate with performance in a particular service application?" is constantly being asked. It was the assignment of the authors of this report to obtain data and opinions on this question from representative rubber technologists.

PROCEDURE AND RESULTS

A questionnaire was submitted to a number of laboratories which the section members felts were most representative of the laboratories interested in abrasion testing and which would be most likely to have data on the correlation of laboratory and field tests. The questions asked were the following:

1. What type of laboratory abrasion tests do you use?
2. What type stocks are tested on the various machines used?
3. What degree of correlation do you find between laboratory and field tests?
4. Do you follow the A.S.T.M. Standards Methods D 394 and, if not, in what respects do your methods deviate?

[1] The B. F. Goodrich Co., Akron, Ohio.
[2] The Goodyear Tire and Rubber Co., Akron, Ohio.
[3] American Cyanamid Co., Stamford, Conn.

Method D 394[4] at the present writing includes three methods for determining abrasion resistance. These are the Du Pont or Williams method, the National Bureau of Standards method, and the U. S. Rubber Co. method.

Other machines which were mentioned in answers to the questionnaire included the Goodyear Angle Abrader described by Vogt,[5] the Lambourn (British Dunlop) machine described by Lambourn,[6] and

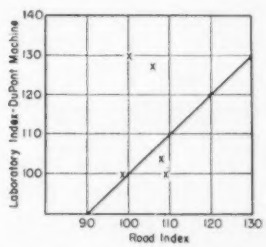


Fig. 1.—Correlation of Laboratory and Road Tests. Data from Laboratory No. 1.

the Goodrich machine not yet described in any publication. In the latter method the sample, in the form of a sheet approximately 0.1 in. thick, is cemented to the periphery of a small diameter pneumatic tire inflated to a fixed air pressure. The wheel on which the tire is mounted is driven against a drum on which the abrasive is mounted. The drum is also driven, but at a fixed differential in surface speed to that of the tire. A controlled stream of dust is allowed to drop on the abrasive for the purpose of preventing its gumming. This method incorporates two features which are departures from the methods previously used. These are the pneumatic cushion and the use of dust to prevent gumming of the abrasive.

The results obtained are given in Tables I to III and Figs. 1 to 5. In addition to data obtained in answer to the questionnaire, additional published data are shown in Figs. 6, 7, and 8.

The conclusions reached after consideration of the answers to the questionnaire are as follows:

1. Reliable data were available only with respect to tire treads. Data and opinions on other products were few and conflicting.

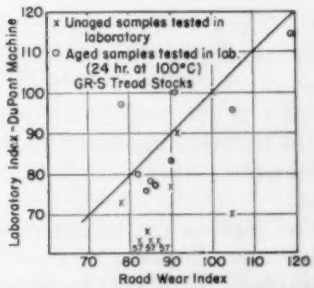


Fig. 2.—Correlation of Laboratory and Road Tests. Data from Laboratory No. 2.

[4] 1946 Book of A.S.T.M. Standards, Part III-B, p. 282.
[5] W. W. Vogt, "Analysis of a Typical Angle Abrasion Machine," *Industrial and Engineering Chemistry*, Vol. 20, p. 302 (1928).
[6] L. J. Lambourn, "Methods of Determining Abrasion With Particular Reference to the Relation Between Road Performances and Laboratory Tests," *Transactions*, Inst. Rubber Industry, Vol. 4, pp. 210–234 (1928).

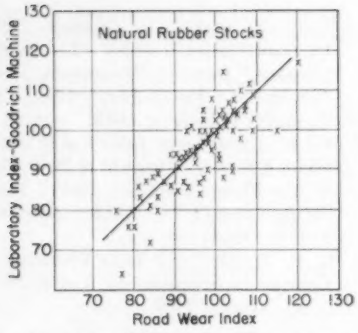


Fig. 3.—Correlation of Laboratory and Road Tests. Data from Laboratory No. 2.

2. There was general agreement that the correlation between laboratory tests and performance of rubber tire treads was fair for most of the abrasion testing machines in use, but the correlation was satisfactory in each case for only a limited range of compounding variations.

(*a*) Correlation is not good if the compounding variations include fatty acid or softener variations.

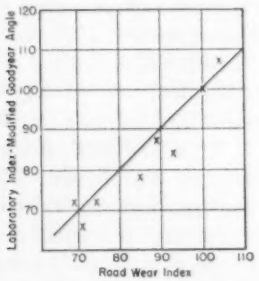


Fig. 4.—Correlation of Laboratory and Road Tests. Data from Laboratory No. 3.

(*b*) Correlation is not good when comparing various base polymers. Several reports indicated that the correlation was less satisfactory for GR-S than for natural rubber.

(*c*) Correlation is not good when comparing radically different compounding techniques.

(*d*) Correlation is not generally good when comparing various grades of carbon blacks.

3. The Du Pont machine is the most popular of those used for tire-tread work. The Goodyear angle abrader is the next most popular. In the footwear industry the Bureau of Standards Abrader is most widely used.

The reasons for failure of correlation are important since they would indicate in what respects present laboratory test methods are inadequate. The following possible reasons for disagreement on tire treads have been deduced from the comments received from various laboratories and from the personal experience of the members of this section:

1. Different road tests will not necessarily rate two different compounds in the same order. This

TABLE I.—TIRES.

Laboratory	Methods Used	Degree of Correlation with Road	A.S.T.M. Methods Used
No. 1	Du Pont	Unsatisfactory—see Fig. 1	Essentially
No. 2	Du Pont	Fair after aging test buttons—see Fig. 2	Essentially
	Goodrich	Fairly good for natural rubber—see Fig. 3	.....
No. 3	Goodyear Angle (modified)	Fair with limitations[a]—see Fig. 4	.....
No. 4	Goodyear Angle (modified)	Fair with limitation[b]	.....
No. 5	None	.....	.....
No. 6	Goodyear Angle	Not reported	.....
	Du Pont	Fair to poor—see Fig. 5	Essentially
	U. S. Rubber	Not reported	Essentially
	Lambourn	Fair with results in about the same order as given by the DuPont machine	.....
No. 7	Goodyear Angle	Good with limitations[c]	.....
No. 8	U. S. Rubber	Good to poor[d]	Some deviation

[a] For comparison of different carbon blacks the correlation is very good. Laboratory tests tend to magnify differences found in service tests. Factory-mixed and tubed stocks should be used rather than laboratory-mixed stocks for best results. Softener variations including fatty acid cannot be successfully compared. Pigment loading variations must be kept within a narrow range. Compounds of widely different compositions cannot be compared.

[b] Correlation is good if the following precautions are observed: (1) A minimum of eight wheels should be tested per compound, (2) tests should be run both before and after oven aging, particularly when GR-S is being tested, (3) an equilibrium running temperature should be attained before a test is started, (4) a standard should be run with each group of experimental wheels, (5) the test wheels should be systematically alternated on the different machine mounts and (6) a minimum of 3 to 4 cu. cm. should be abraded from the sample.

[c] Carbon black variations give good correlation between laboratory and road tests. Fatty acid variations do not. This test is less sensitive to modulus or hardness variations than other methods.

[d] High fatty acid content introduces an appreciable error. Correlation for GR-S compounds poorer than for natural rubber.

TABLE II.—HEELS AND SOLES.

Laboratory	Laboratory Method Used	Degree of Correlation	A.S.T.M. Method Followed
No. 1	Bureau of Standards	Fairly good	Yes
No. 2	Bureau of Standards	Fair	Essentially
No. 3	DuPont	Doubtful[a]	Essentially—2½ garnet paper used
No. 4	Bureau of Standards	Fair[b]	Yes
No. 5	Bureau of Standards	Fair with limitations[c]	Yes
No. 6	Bureau of Standards	Fair with limitations[d]	Essentially

[a] For best correlation the compounds tested must be in the same hardness range, have approximately the same state of cure, and contain the same amount and type of softeners.

[b] Correlation is not very accurate. It is better for natural rubber than for GR-S.

[c] When minor compounding variations are tested the correlation is fair. When widely different types of compounds are tested it is poor.

[d] Fair for materials of similar composition only. Plastics or high resin stocks give false results.

TABLE III.—MISCELLANEOUS.

Laboratory	Laboratory Method Used	Products	Degree of Correlation	A.S.T.M. Method Followed
No. 1	Du Pont	No specific product	No data	Essentially
No. 2	Du Pont	Belt covers—chute linings	No data	Essentially
	Wyzenbeek	Elastic plastics	Thought to be fair	.....
No. 3	Du Pont	Hose and belt covers, Chute and tank linings[a]	Doubtful Doubtful	Yes
No. 4	Du Pont	No specific product	No data	Essentially

[a] Satisfactory for distinguishing good from poor compounds and for control purposes. It does not distinguish small differences. Because of the wide variety of conditions to which these products are subjected in service, precise correlation would not be expected.

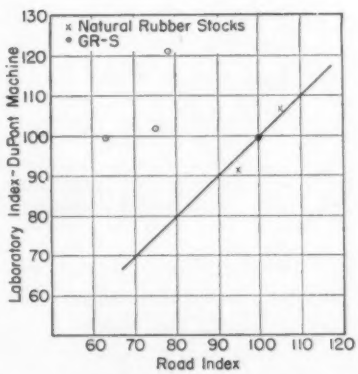


Fig. 5.—Correlation of Laboratory and Road Tests. Data from Laboratory No. 6.

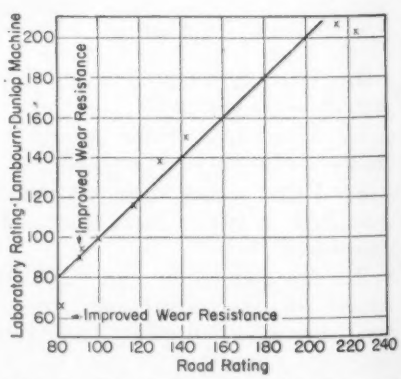


Fig. 6.—Correlation of Laboratory and Road Tests. Data from Lambourn. (I.R.I. 1928–1929, Vol. 4, pp. 210–234.)

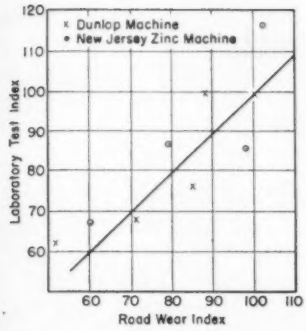


Fig. 7.—Correlation of Laboratory and Road Tests. Data from report of Subcommittee XIV, India Rubber World, Vol. 81, No. 2, Nov. 1, 1929.

might occur if the two tests were run under different conditions, as, for example, if the tire designs were different, if the average temperature during the road tests were different, or if the abrasive character of the road surfaces were different. Thus, if road tests do not invariably rate a series of compounds in the same order, a precise correlation between laboratory tests and *all* road performance tests is not possible.

2. The state of cure is usually not the same in the laboratory test specimen and in the tire tread. If there were a constant difference this would not be as objectionable, but the probabilities are that it is variable.

3. If the laboratory test specimens are made from stock mixed on a laboratory mill, the degree of pigment dispersion and the amount of breakdown of the rubber is likely to be appreciably different from the factory mixed stock used on the tire.

4. The rate of wear changes in the course of a tire test due to the stiffening or softening resulting from continued cure or aging. This factor may at times be responsible for reversing the relative position of two stocks. This does not occur in laboratory tests, at least to the extent that it does in service.

5. Laboratory tests are usually made to proceed too fast. The nature of the abraded surface and the particles removed indicate a somewhat different process than occurs on the road.

6. The temperature coefficient of abrasive wear is quite high and is different for different stocks and different polymers. Laboratory tests may and probably do rate the various stocks at a different temperature level from road tests.

7. The abrasion of a tire tread is intermittent, a particular point on the tread contacts the road only once in each revolution. Many of the laboratory tests are continuous.

8. Laboratory tests tend to overemphasize the effect of high modulus. This is probably associated with the difference in cushioning of the test specimen, that is, a pneumatic cushion in the tire and only the deflection of a relatively thin block of rubber in the laboratory test. (The Goodyear angle abrader is somewhat better in this respect than the Du Pont machine and the Goodrich method eliminates it by the use of a pneumatic cushion.)

9. Laboratory tests are frequently erratic due to the abrasive becoming filled up or rendered gummy by the character of the stock being tested. This does not occur on the road, primarily for the reason that the abrasive track is being constantly renewed.

Many of these points were brought out in the discussion following the Symposium on Abrasion Testing of Rubber.[7] Specifically, the difficulty of duplicating road ratings from time to time, the temperature effect, the exaggeration of the modulus effect in most laboratory tests, and the problem of gumming of the abrasive track were discussed.

One of the most consistent objections to results from laboratory tests is that of gumming the abrasive. Because of this constantly recurring complaint it would be desirable if some attention could be given to eliminating this difficulty, either by the method of dusting or by using a continuously renewed track. Other methods such as the suggestion that the samples be extracted prior to testing might be considered.

There appears to be no immediate necessity for revising the methods as they now appear in A.S.T.M. Standard D 394. This is based on the results of the questionnaire which showed that the present methods are followed with but minor deviations.

Because of the popularity and generally good experience with the Goodyear angle abrader, some consideration should be given to including this method in Standard D 394.

[7] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part II, p. 895 (1931).

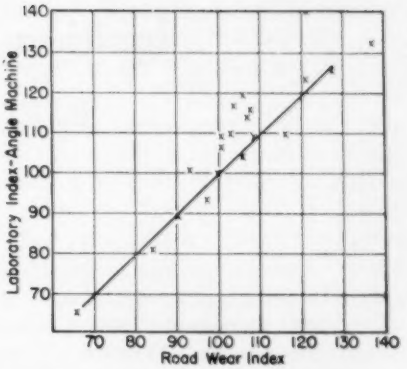


Fig. 8.—Correlation of Laboratory and Road Tests. Data of J. L. Tronson and A. W. Carpenter, "Abrasion Tests of Vulcanized Rubber Compounds Using an Angle Abrasion Machine," Proceedings, Am. Soc. Testing Mats., Vol. 31, Part II, p. 908 (1931).

Summary

There appears to have been no substantial improvement in the degree of correlation between laboratory abrasion tests and service tests on rubber tires since the 1931 Symposium on Abrasion Testing of Rubber.[6] The limitations with respect to compounding variations are essentially the same today as then.

The data on rubber products other than tires are too few to permit any conclusion to be drawn.

The reasons for the failure of laboratory tests to correlate with road results are many and varied. Some of these are listed in this report. They represent not only weaknesses in the laboratory procedures, but also difficulties in standardizing service tests.

A better laboratory test method should incorporate the following features:

1. Cushion the test specimen to minimize the modulus effect.
2. Provide means to prevent gumming of the abrasive.
3. Provide means to conduct the test over a range of temperatures.
4. Slow the rate of wear, partly by abrading intermittently and partly by use of less load and duller abrasive.
5. Use a test specimen of a size which can be cut from a tire tread if desirable.

Ignition Temperatures of Rigid Plastics

By E. M. Schoenborn[1] and D. S. Weaver, Jr.[1]

SYNOPSIS

The temperature at which a plastic will ignite and the rate at which it burns may be considered as two separate and independent measurable properties. This paper describes a method for evaluating the first property, the surface temperature at the moment of ignition, in a manner considered to be more rigorous than any heretofore available. Flammability data are presented for over twenty five different materials under a variety of test conditions.

By measuring the actual temperatures which prevail at known points within a specimen at the instant of ignition it is possible to evaluate an apparent ignition temperature for the surface. This temperature value is found to depend primarily upon the nature of the substance and upon the temperature of the heat source. At any given furnace temperature, it is also shown that the apparent ignition temperature is a function of the time required to ignite the specimen. This relationship is essentially independent of the nature of the materials tested and appears to hold over a wide range of temperatures and times.

Results obtained on the thermosetting and thermoplastic types investigated preclude the establishment of a single furnace temperature for all materials.

The probable mechanism of ignition is discussed. A rigorous analysis of the flammability problem is complicated by a lack of information on the thermal properties of and by the difficulty of applying unsteady state heat transfer theory to materials which deform, decompose, or are otherwise thermally unstable at the temperatures involved.

THE flammability characteristics of rigid plastic materials do not appear to have received at the hands of the standard authorities the attention and sustained investigation which other properties have received. Application of data for engineering and design purposes emphasizes the need not only for increased precision in the test method but also for sound interpretation of results in the light of fundamental relationships. Prediction of the behavior of a given material under a wide variety of conditions and uses is possible only when such relationships are clearly understood.

Organic plastic substances differ essentially from the common structural materials—the metals, ceramic ware, glass, concrete, etc.—in their inability to withstand high temperatures. Although most of the modern plastics were not developed for high-temperature work, there are many applications wherein the ease with which they can be ignited and the rate at which they will burn are of paramount interest.

Problems relating to flammability of the so-called rigid plastics are of real importance, even though interest is no doubt greatest in the case of finely divided materials, films, and thin sheets. Even the self-extinguishing types may be hazardous under certain environments. Thus, simple, rapid, and reliable means should be available for evaluating not only the tendency of plastics to ignite and sustain flame but for predicting their performance under extreme thermal conditions.

The flammability characteristics of plastics comprise two distinct measurable properties: (1) the *temperature* at which incipient combustion takes place, and (2) the *rate* at which combustion proceeds. Review of the available literature and preliminary investigation have shown that each of these is essentially independent of the other. For purposes of test, therefore, consideration of each one separately appears to be of distinct utility. The present investigation was undertaken with a view toward developing a sound method for determining the first of these characteristics using simple, straightforward test procedures and, simultaneously, toward securing a body of useful physical data on a wide variety of typical commercial materials. A subsequent study will deal with the burning rate of such materials in an attempt to correlate the two phases of the problem.

PREVIOUS WORK

An examination of available literature in the plastics field has revealed only a limited amount of information on the flammability characteristics of these materials. Specific data characterizing a given substance are few and scattered, and most of these are concerned with burning rate rather than temperature of ignition. Standard texts and reference books give only brief consideration to the problem and then only in connection with thermal stability. Comparative flammabilities of a selected number of materials, when reported, are usually qualitative in nature while the nonflammability of others is stressed in trade publications and manufacturers' bulletins. Attempts at providing quantitative measurement of these properties have been advanced by the American Society for Testing Materials, the technological divisions of the Armed Services, and by the National Board of Fire Underwriters. Most of the test procedures are somewhat alike in principle and differ only in their applicability to materials of various forms.

A general survey of current testing methods is given in recent editions of the Plastics Catalog (5),[2] and an excellent summary of the philosophy and techniques of testing is provided by Stock (7).

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Professor of Chemical Engineering and Research Fellow in Cemical Engineering, respectively, North Carolina State College, Raleigh, N. C.

[2] The boldface numbers in parentheses refer to the references appended to this paper.

Aspects of safety and fire protection as they relate to the plastics industry are discussed in a recent report of the National Board of Fire Underwriters (4). In addition to data relating to the fire hazard properties of flammable materials used in plastics processing, a comparison in tabular form of the thermal properties and burning characteristics of the principal groups of plastics is provided. Resistance to heat, softening point, distortion under heat, burning rate, ease of ignition, character of flame, and odor on burning are listed. The comparative combustibility of various plastics is also indicated by classifying them according to three principal groups: (1) those plastics which burn at a rate comparable to that of cellulose acetate or somewhat less than that of common newsprint; (2) those which burn with a feeble flame which may or may not propagate away from the point of ignition; and (3) those burning only during the application of the test flame.

A number of test methods for evaluating the burning characteristics of various materials have been adopted as standard and several novel methods are described in the literature. The burning rate of plastic films and thin sheets 0.05 in. or less in thickness is determined (8)[3] by suspending a strip specimen in a draft-free enclosure and igniting the lower end by means of a pyroxylin fuseé or by a drop of benzol. The length of time that the material continues to burn and the area of the burned portion of the test specimen are taken as a measure of the flammability of the material. In testing sheets or plates over 0.05 in. in thickness[4] similar principles apply but the strip is held horizontally over a wire gauze and the free end ignited with a bunsen burner. If the material does not continue to burn under prescribed conditions it is reported as "self-extinguishing."

Self-extinguishing types of plastics in the form of sheets or plates $\frac{1}{8}$ in. in thickness are brought into contact with a surface at bright red heat.[5] Burning rate of the narrow strip is measured in inches per minute and heating is obtained by use of a globar element at 1740 F. Treated textile fabrics are tested for evaluation of fire-retardant properties[6] by igniting a vertical strip of the cloth with a bunsen burner and noting the duration of flaming and length of char. Treated paper and paperboard are evaluated[7] in a similar manner.

Rubber insulated wire and cable may be subjected to a flame test[8] in which a somewhat different technique is employed. The lower end of a vertical specimen of the wire is periodically heated under prescribed conditions. The wire is considered to have conveyed flame when 25 per cent or more of the extended portion of a paper indicator, previously attached about midway along the length of the wire, is burned after five applications of the flame. A somewhat similar test procedure is employed for determining the flame-retardant properties of wire and cable insulated with a polyvinyl compound.[9]

Sheet and plate materials used in electrical insulation such as phenolic and other types of laminated sheets, hard rubber, asbestos composition board, etc., are tested for flammability[10] by evaluating the tendency of the material to burst into flame under the continuous application of heat. The test specimen is heated by means of resistance wire wound about it in the form of a spiral and the time required for the sample to burst into flame is noted. The burning rate of varnished tubing used for electrical insulation is determined[11] by placing one end of the specimen in a bunsen flame until ignition takes place, withdrawing it, and noting the time for the leading edge of the flame to travel a predetermined distance along the tube.

The fire-retardant properties of wood can be measured[12] by igniting with a calibrated Meker burner flame a number of small specimens stacked in tiers on a ring stand. After application of the flame for a specified period of time the burner is withdrawn and when all flaming and glowing has ceased, the specimens are removed and weighed. The loss in weight expressed as a percentage of the original conditioned wood is taken as a measure of the fire-retardant properties of the sample.

Hartmann and Nagy (3) investigated the ignition temperature and relative flammability of a wide variety of fine powders used in the plastics industry. The materials investigated included resins, molding powders, fillers, and some of the primary ingredients of resins. The minimum ignition temperature was taken as the lowest temperature of an electrically heated, vertical, cylindrical furnace at which a weighed dust sample ignited when blown into the chamber. The relative flammability was determined by ascertaining the amount of an inert dust required in the mixture with the inflammable dust to prevent ignition and flame propagation when dispersed in the presence of a standard source of ignition. Two types of apparatus were employed in these tests: one, the apparatus referred to above when the furnace was held constant at a temperature of 1292 F. and the second, an open-spark apparatus in which the powder (containing the inert material) was blown between two tungsten electrodes located inside a pyrex glass tube. The effects of such variables as maximum pressure, concentration or density of dust, particle size, moisture content, etc., on the explosibility were also studied. Comparison of the data with those for other materials showed that many plastic powders may be as hazardous as inflammable metals such as aluminum and magnesium, as well as some of the common carbonaceous dusts such as coal and corn starch.

[3] Standard Method of Test for Flammability of Plastics 0.050 in. and Under in Thickness (D 568 – 43), 1946 Book of A.S.T.M. Standards, Part III-B, p. 204.

[4] Standard Method of Test for Flammability of Plastics Over 0.050 in. in Thickness (D 635 – 44), 1946 Book of A.S.T.M. Standards, Part III-B, p. 207.

[5] Tentative Method of Test for Flammability of Plastics, Self-Extinguishing Type (D 757 – 44 T), 1946 Book of A.S.T.M. Standards, Part III-B, p. 846.

[6] Tentative Specifications for Fire-Retardant Properties of Treated Textile Fabrics (D 626 – 41 T), 1946 Book of A.S.T.M Standards, Part III-A, p. 1048.

[7] Standard Method of Test for Flammability of Treated Paper and Paperboard (D 777 – 46), 1946 Book of A.S.T.M. Standards, Part III-B, p. 391.

[8] Tentative Methods of Testing Rubber Insulated Wire and Cable (D 470 – 46 T), 1946 Book of A.S.T.M. Standards, Part III-B, p. 1155.

[9] Tentative Specifications for Insulated Wire and Cable: Polyvinyl Insulating Compound (D 734 – 43 T), 1946 Book of A.S.T.M. Standards, Part III-B, p. 1136.

[10] Standard Methods of Testing Sheet and Plate Materials Used in Electrical Insulation (D 229 – 46), 1946 Book of A.S.T.M. Standards, Part III-B, p. 36.

[11] Standard Methods of Testing Flexible Varnished Tubing Used for Electrical Insulation (D 350 – 45), 1946 Book of A.S.T.M. Standards, Part III-B, p. 61.

[12] Standard Method of Test for Combustible Properties of Treated Wood by the Crib Test Method (E 160 – 46), 1946 Book of A.S.T.M. Standards, Part II, p. 1215.

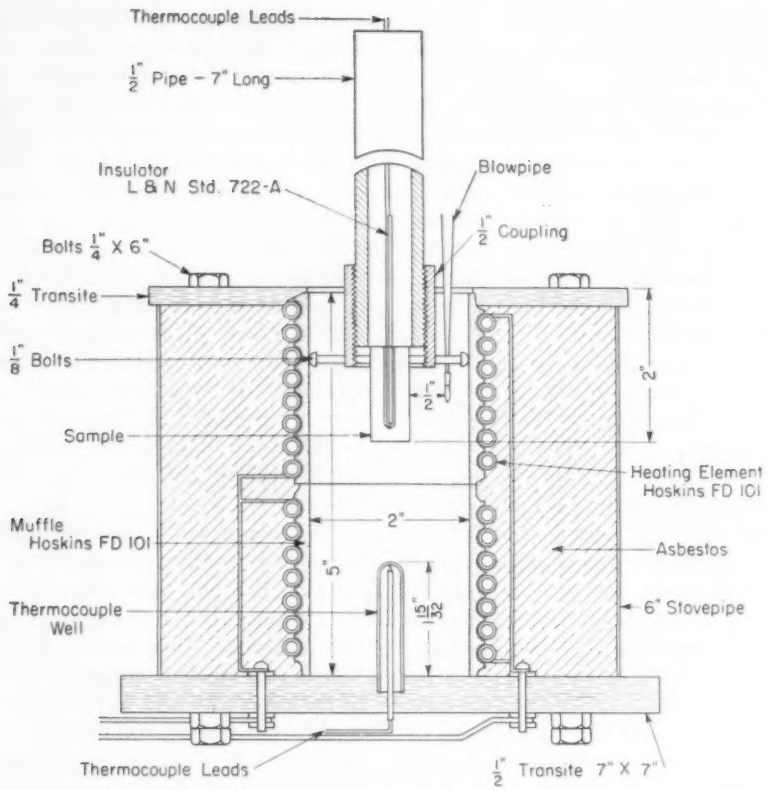


Fig. 1.—Diagrammatic Sketch of Apparatus.

The flame resistance of a group of thermosetting plastics has been investigated by Gale. Stewart, and Alfers (2). The method is an extension of that mentioned above for the self-extinguishing types. In place of the globar element, a nichrome wire coil is used as the heating element, the specimen being supported in a vertical position within the coil. Materials are rated in terms of ignition time, or time required to ignite the specimen after the coil is energized; and burning time, or time required for self-extinction of the flame after the coil current is cut off. The amount of distortion caused by burning is noted, and, where possible, the mechanical strength of the sample after test is determined. The method was applied only to the self-extinguishing types (thermosetting) and no data on other widely used materials such as the thermoplastics are reported.

The ignition points of plastic materials were studied by Delmonte and Azam (1) who concerned themselves solely with those specific temperatures at which plastic materials would spontaneously burst into flame. Their method comprised the measurement of the lowest temperature of a molten mass of sodium hydroxide which would cause ignition of thin samples when brought into contact with the surface of the bath. Although both the minimum ignition temperatures and ignition times were measured for a variety of materials, data for individual tests were not reported. Two separate ignition points, however, were noted: one, the minimum temperature ±25 F. at which ignition was first observed and at which temperature the sample may have been held in contact with the molten base as long as ten seconds; the other, the temperature at which instantaneous ignition (less than 1 sec.) was observed. The variation between these two temperatures was often as much as 200 F. Results were reported in the form of a chart, the ignition points being shown in descending order on a vertical temperature scale.

Experimental

Apparatus:

A diagrammatic sketch of the apparatus developed for the present study is shown in Fig. 1. The heating unit consists of a cylindrical refractory core 2 in. in inside diameter by 5 in. long, on the outside of which is wound a resistance heating element. Two commercial Hoskins heating units type FD101 such as are used in muffle furnaces were found to be satisfactory. These elements are mounted on a piece of transite ½ in. thick and 7 in. square, covered with a layer of asbestos approximately 1¾ in. thick, and bolted between a transite cover and the base with tie rods.

Furnace temperatures are determined by means of a thermocouple located in a refractory sheath near the bottom center of the combustion space. The thermocouple well is accurately centered and extends vertically upward a distance of 1 15/32 in. from the transite base. Preliminary temperature traverses made across a diameter and at different depths within the furnace showed considerable variation of temperature with position of the thermocouple junction. Furthermore, the temperature varied widely with the type of base closure. Temperature profiles at different depths were carried out with the bottom of the heating chamber open and also with disks of several diameters centered in the opening. Temperature patterns were highly erratic due to increased convection and draft from the bottom upward. Thus with any type of opening in the bottom the enclosure behaved as a chimney and careful regulation of the furnace temperature was practically impossible. Best results were obtained with a closed furnace base

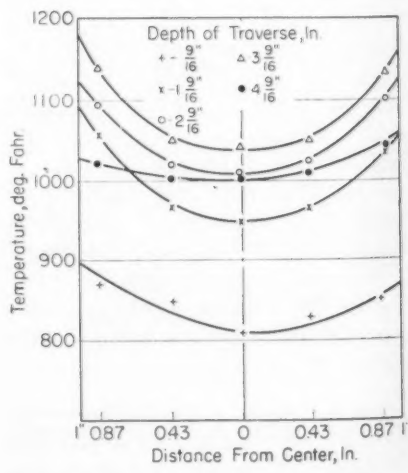


Fig. 2.—Furnace Temperature Profiles versus Thermocouple Depth.

as shown. Figure 2 illustrates the types of temperature traverses secured for this case. As might be expected, temperatures are at a minimum in the center of the enclosure and vary with the vertical distance. Air currents due to free convection near the mouth of the opening lower the temperature prevailing at the upper end of the unit. Since for present purposes the exact position of the thermocouple is purely arbitrary, the location chosen was adopted simply for convenience and relative ease of temperature reproduction.

The data of Fig. 2 point out rather forcefully the magnitude of the error involved when the temperature at some point in the heat environment is taken as the sole measure of the ignition point of a sample.

By controlling the current input to the heater windings (using an ordinary rheostat and ammeter in series) furnace temperatures can readily be set and maintained at any predetermined value up to approximately 1400 F. For the apparatus described and employing 110 v. a.c., a current of 2.7 amp. corresponds to a furnace temperature of about 700 F.; while 5.2 amp. corresponds to about 1400 F.

To hold the specimen at a given fixed position with respect to the heated wall, a simple fixture made up of a short length of $\frac{1}{2}$-in. standard iron pipe and a coupling is employed. Four small bolts screwed through the lower end of the coupling center the specimen accurately within the fixture. The entire sample assembly is connected to a ring stand and can be raised or lowered at will.

A small gas jet for ignition of inflammable gases from the sample is provided by a blowpipe which is also clamped in position on the ring stand. Gas flow rate is adjusted to give a flame about $\frac{1}{4}$ in. in length and the flame is situated approximately $\frac{1}{2}$ in. from one side of the sample. The heat emitted from this flame is small compared with that supplied by the heater, but use of the auxiliary flame aids greatly in obtaining a clearly defined point of ignition, particularly with those materials which have a tendency to flash before burning. As some materials approach the kindling temperature, bright blue flashes are noticeable for a short period of time; as heating continues a yellow flame suddenly appears and the sample ignites.

The apparatus is set up and all tests are carried out in a laboratory fume hood in order to minimize drafts. On completion of a test, the blower is turned on for a short period to clear the hood of smoke and any noxious fumes resulting from the combustion of the materials.

Specimens:

In all cases specimens are prepared by cutting $1\frac{1}{4}$-in. lengths from a $\frac{1}{2}$ by $\frac{1}{2}$ by 5-in. bar such as is commonly used in flexure and impact tests. Although use of round rods would have been more desirable from an academic point of view, the ease of securing specimens of this size and shape precluded use of other types. It is planned, however, to study round rods and other shapes at a later date to determine the possible effect of sample form (should such an effect be found to exist).

For admitting the thermocouple, each sample has a $\frac{3}{32}$-in. hole drilled in the center of one end. These holes are drilled to different depths in a series of samples of each material. At least one hole is drilled as close as possible to the farther end without piercing the sample. The thickness of the wall between the lower outside surface and the end of the hole is then measured carefully using a suitable gage and micrometer, thus locating with precision the junction of the thermocouple within the sample.

Temperature Measurements:

All temperatures were obtained using standard 30 B. & S. gage iron-constantan thermocouples. Junctions were carefully made by winding the ends of the wire tightly together, welding them at the initial point of contact, and removing any excess metal from the end so that the junction could be accurately located with respect to the specimen surface. At the high temperatures involved, insulation of the leads is imperative. This was accomplished by use of standard 722-A Leeds & Northrup ceramic insulators, which fit snugly into the upper end of the holes in the specimens.

Specimen temperatures were read in deg. Fahr. using a Brown Electronik potentiometer having a range of 0 to 2000 F. This instrument is a self-balancing type which permits instantaneous values to be read as rapidly as the eye can perceive them. A Leeds & Northrup semiprecision potentiometer was also employed for obtaining furnace temperatures and for checking the various thermocouples used throughout the work.

Procedure:

Prior to starting any series of tests, all specimens were conditioned in accordance with the A.S.T.M. tentative method of conditioning, D 618.[13] Certain materials, particularly the cellulosic types and those containing cellulosic fillers, are sensitive to environmental changes. Since the moisture content might be expected to affect the ignition characteristics of a material, it appears desirable to erase, if possible, any previous differences in history before subjecting the specimens to the heating process.

Before introducing the specimen into the furnace, the latter was allowed to heat up to the desired temperature. This was usually done with the specimen holder in place (but without sample), the current to the heaters being adjusted until the furnace thermocouple reached the proper value. The sample with its thermocouple previously affixed was then lowered into the furnace and a stopwatch started. The time and temperature of the specimen were usually read at intervals of approximately 100 F. until ignition was observed to have taken place. Additional readings were occasionally taken after ignition if the time-temperature relation for the specimen in question was desired. Following ignition, the specimen was withdrawn, the flame extinguished, and the specimen removed for observation.

Typical time-temperature curves plotted from such data are shown in Fig. 3. It is readily seen that at the moment of ignition a sharp upward break occurs in the heating curve. The "break point" in this curve was found to agree closely with values

[13] Tentative Methods of Conditioning Plastics and Electrical Insulating Materials for Testing (D 618 – 46 T), 1946 Book of A.S.T.M. Standards, Part III-B, p. 540.

TABLE I.—SUMMARY OF RESULTS.

Material	Number of Specimens per Test	Furnace Temp., deg. Fahr.	Ignition Time, sec.	Apparent Ignition Temp., deg. Fahr.
Phenolic, wood flour filled	10	930	97.1	660
	6	880	173	680
	6	850	190.2	730
	9	850	222.5	750
	8	850	192.2	740
Phenolic-cresyllic, paper laminate	8	850	108.2	479
	7	850	128.2	500
	7	850	91.4	449
	8	780	184	552
Phenolic-cresyllic, canvas laminate	8	780	173	615
	12	750	208.6	685
	4	1000	48.3	407
	11	900	86	420
	6	850	85.5	500
	8	850	101.6	520
Phenolic-cresyllic, asbestos paper laminate	6	850	68.5	497
	7	780	137	520
	8	780	146	560
	8	750	162	640
	4	1000	55	410
Phenolic, mineral filled	8	850	98.3	470
	8	850	102.8	485
	8	850	81.6	485
	11	800	226.8	665
	7	780	244	710
	6	780	234	725
	8	750	254	830
	11	1160	83.7	725
	7	1030	149	830
	6	1030	145.1	830
	7	1000	148.1	975
Allyl diglycol carbonate	6	..	670	720
Vinylidene chloride	7	1200	32.6	400
	5	1200	18.6	380
	9	1100	27.4	345
	18	1000	41.6	332
	9	900	63.3	460
	16	850	84.5	458
	16	850	93.8	465
Bone fiber	8	770	188.1	520
	8	770	218.7	510
	8	730	197	570
	6	730	164.2	570
	7	730	215	560
	9	700	206.2	582
	9	700	209.4	575
	10	700	198.3	580
	8	700	222	560
	8	1000	71.9	395
	11	850	110.8	405
Urea-formaldehyde, alpha cellulose filler	6	850	137	4 0
	5	850	135.5	408
	11	810	132	400
	8	730	276	460
	8	730	199	480
	6	700	261	480
	7	1000	48.1	355
	10	880	129.6	440
Melamine-formaldehyde, wood flour filler	7	850	109	450
	6	850	111.2	470
	7	780	192.8	585
	4	780	161.8	645
	7	750	185	650
Polystyrene, compression molded	7	1030	31.8	320
	7	1030	38.7	425
	7	1000	40.8	430
	6	850	89.6	495
	8	850	76.7	475
	7	850	86.8	470
Vinyl chloride acetate grade 2, A.S.T.M. white[a]	5	1030	24.6	210
	8	1030	22.6	295
	10	1000	27.1	330
Vinyl chloride acetate grade 2, A.S.T.M. clear	5	850	63.6	380
	8	850	66.9	375
	6	850	74.4	390
	5	850	46	305
	7	850	47.5	265
	8	850	50.3	300
Vinyl chloride acetate VE-5521	3	850	48.2	309
	17	850	43.0	232
Cellulose acetate-butyrate	3	1030	31.1	240
	4	1030	30.1	250
	2	850	54.3	320
Cellulose acetate 591-38-1	4	850	55.0	320
	4	1030	22.2	200
	7	1030	22.3	310
Cellulose acetate 418-16-8c	4	850	34.3	230
	4	1030	24.1	2 0
	8	1030	23.4	255
Cellulose acetate 591-38-3	4	850	43.4	247
	8	1030	27.8	270
	4	850	46.1	246
Cellulose acetate 591-38-8	3	850	47.1	250
	7	1030	24.0	294
Cellulose acetate 591-38-8C	4	850	34.7	220
	4	850	41.9	184
Cellulose acetate 591-38-7	4	1030	21.9	260
	3	1030	28.4	310
Cellulose acetate 591-49	3	1030	20.3	245
	6	1030	22.2	250
Ethyl cellulose 678-20-2	4	1030	21.3	200
	6	1030	22.2	320
678-20-5	6	850	43.7	270
Ethyl cellulose 678-24-2	4	850	43.1	250
	4	850	38.9	290
Ethyl cellulose 678-24-5	4	850	40.6	270
	4	850	41.2	280
Ethyl cellulose 678-28-5	4	850	46.4	270
	4	850	52.5	270
Methyl methacrylate[b]	4	850	53.8	300
	4	850	49.6	262
Polyethylene	4	850	55.5	270
	13	850	55.0	295
	18	850	49.0	360

[a] Cut from ⅜-in. stock. [b] Cut from ½-in. rod.

observed visually, so that an operator reasonably familiar with the technique might safely rely on observation alone to determine this point. In the present study, the visual procedure was employed throughout, time - temperature curves being plotted only where doubt existed as to the accuracy or reproducibility of the results.

It must be emphasized that these "break points" are not to be construed as the ignition temperature of the specimen. Rather they are the local temperatures existing at a given position within the sample when combustion begins at the outer surfaces. The apparent ignition temperature is subsequently

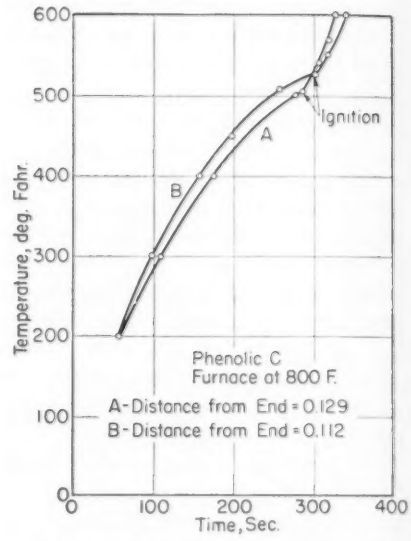


Fig. 3.—Time-Temperature Curves.

found by plotting the "break point" temperatures *versus* the distance between the outer bottom surface and the thermocouple junction and then extrapolating this curve to zero distance (specimen surface). The temperature read from such a plot is arbitrarily defined as the apparent surface temperature at the moment of ignition.

Discussion of Results

The results obtained using 28 different plastic materials are summarized in Table I. The number of separate specimens employed, the operating furnace temperature, the time required for ignition, and the apparent ignition temperature are given. Detailed data secured during individual tests will be reported in a subsequent publication (6). All of the specimens were taken to be representative of commercial ma-

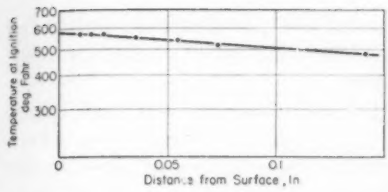


Fig. 4.—Ignition Temperature versus Thermocouple Depth. Melamine-formaldehyde-wood flour filled. Furnace temperature, 780 F.

terials and were supplied through the generosity of the manufacturers. For obvious reasons, no further identification than that indicated in Table I is included.

Inspection of these data reveals that a considerable range of ignition temperatures and ignition times exist for the particular plastics tested. Lowest ignition temperatures were obtained for a vinyl chloride acetate product, highest values for a mineral-filled phenolic. Specimens of polytetrafluorethylene could not be ignited under any conditions with the heating unit employed. In general, the thermosetting types exhibit better resistance to high temperatures in so far as combustibility is concerned than do the thermoplastics, although certain in the latter group, of which polystyrene is an example, rank high in the ignition point scale. It is difficult at this stage of development of the method to apply any rigid classification scheme to the materials in question since they cover such a wide range of types and compositions. It is hoped that as additional data become available the contribution of such factors as the amount and kind of filler, degree of cure, amount and kind of plasticizer, or other special additives may be ascertained through evaluation of such thermal properties.

The manner of arriving at the apparent ignition temperature of a material is illustrated by the curves shown in Figs. 4 and 5. In each of these the temperature indicated by the specimen thermocouple at the point of ignition has been plotted on semi-logarithmic coordinates against the linear distance separating the junction from the lower surface. The temperatures read from such a plot by extrapolating the curve to zero distance (surface) are taken as the apparent ignition temperatures. Use of the term "apparent" ignition temperature is preferred here since there appears to be some doubt as to the justification for such an extrapolation to arrive at a true surface temperature. It is well known that most plastic materials are dimensionally unstable at high temperatures, and this fact has been borne out by inspection of the specimens during the heating process. Thus, the distances plotted are not those corresponding to the actual values at the point of ignition but rather to the initial dimensions determined prior to heating. The extent of dimensional stability varies widely with type and form of material; from those which swell or shrink slightly as the temperature is raised

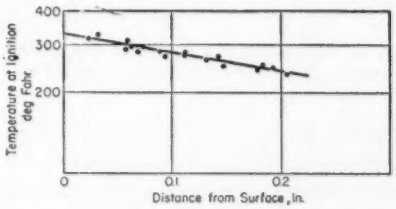


Fig. 5.—Ignition Temperature versus Thermocouple Depth. Bone fiber. Furnace temperature, 1000 F.

to those which soften and melt or deform completely. The relative degree to which a material is thermally stable under the conditions described is evinced by the amount of scattering of the data when plotted in this manner. The data for melamine-formaldehyde and for vulcanized bone fiber (Figs. 4 and 5, respectively) are typical of the more stable variety, and extrapolation of their temperature-distance curves is simple and straightforward. Data obtained with certain other substances, notably vinyl chloride acetate and vinylidene chloride, scatter widely and the best curves representative of the results are consequently more difficult to locate. In the case of the more readily deformable varieties, it was found desirable to space the thermocouples nearer the outer bottom surface, that is to use deeper holes, so that the extent of extrapolation is decreased. It should be mentioned that a logarithmic temperature scale is employed since the data exhibit practically straight lines on this type of plot and, furthermore, because such a method of plotting possesses the advantage that equal linear increments on such a scale represent equal percent age changes in the variable plotted.

Although the rate of arrival of heat to the surface of the specimen and the rate of temperature rise of the surface, therefore, would be expected to depend on the furnace temperature, the surface temperature at which ignition takes place would at first thought appear to be independent of the furnace temperature provided it is well above the ignition point. It was, in fact, hoped that the ignition temperature would be independent of the temperature of the environment—or at least approach some asymptotic value at sufficiently high furnace temperatures. That such is not the case is clearly seen from the data. Dependence of both time and temperature of incipient combustion on the temperature level of the heat source introduces a complication which, although not irreconcilable, poses the additional problem of furnace control. In general, the surface temperature and time to ignite decrease with increasing furnace temperature and at a rate which appears to depend also on the nature of the plastic. This is shown for a sample of phenolic laminate and of bone fiber in Figs. 6 and 7, respectively. Similar data for other materials show the same general trends but with differing slopes and degrees of curvature. That the possibility of independence of the furnace temperature exists is evidenced by the several points of nearly constant ignition temperature at the highest values of furnace temperature. Considerably more data are needed before this trend can be ascertained with certainty.

Importance of the furnace temperature is stressed in other ways. Attempts were made, as inspection of the tabulated results show, to established a fixed furnace tempera-

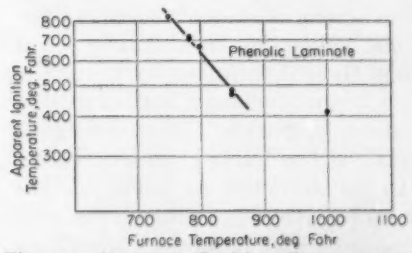


Fig. 6.—Apparent Ignition Temperature versus Furnace Temperature. Phenolic laminate, paper-base.

ture for all materials tested. By eliminating this variable, attention could be directed essentially to the time-ignition point relationship. Unfortunately it is not yet possible in the light of present data to fix arbitrarily such a furnace temperature. Materials such as a mineral-filled phenolic and polytetrafluorethylene require a very high temperature environment (above 1000 F.), below which actual flame propagation cannot proceed or below which the time for the initial flame to appear is exceedingly great. On the other hand, a material such as the allyl diglycol carbonate cannot be introduced even into a moderately heated environment. When exposed to high temperatures, specimens of the latter material disintegrate rapidly and completely, sometimes with explosive violence, so that the sample must be introduced into a cold furnace and the heating carried out slowly until ignition takes place (around 730 F.).

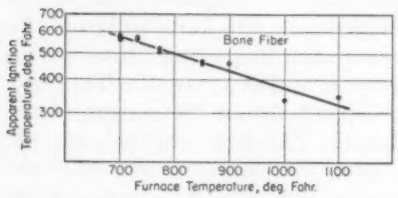


Fig. 7.—Apparent Ignition Temperature versus Furnace Temperature. Bone fiber.

With the exception of two or three of the plastics tested, it was found that the bulk of the group could be handled in a fairly satisfactory manner at a furnace temperature of 850 F. A comparison of apparent ignition temperatures on this basis is shown in the bar chart of Fig. 8. The mineral-filled phenolic is the only exception since, as mentioned previously, a furnace temperature of 1000 F. was necessary to cause burning and it is included merely to extend the range of values covered. Despite the known variation among plastics of the same type, these values are considerably lower than those determined by Delmonte and Azam (1) using a bath of molten sodium hydroxide. From the standpoint of fire hazard, present values can be accepted as being on the conservative side, although the relative order may be subject to revision as additional data become available.

Theoretical considerations of heat

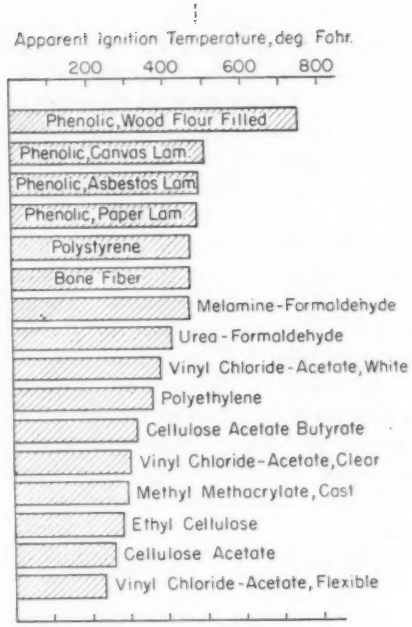


Fig. 8.—Comparative Ignition Temperatures. Furnace temperature, 850 F.

transfer as applied to the probable ignition mechanism emphasize the importance of the time factor as well as of the temperature. For a given furnace temperature, the time required to cause the surface of a specimen to ignite should be related to the temperature difference between heating unit and sample. Thus, the time required for ignition should be roughly proportional to the ignition temperature, so that a substance having a low ignition point might be expected to ignite more rapidly under a given set of conditions than one having a higher value. The dependence of time on the ignition temperature is shown in Fig. 9 for those materials tested at a constant furnace temperature of 850 F. Although the data are not sufficient to establish an exact relationship between these variables, such a correlation possesses definite merit in providing an additional means for evaluating flammability characteristics. In fact, measurement of ignition time may prove a more convenient method of arriving at the answer to the general problem, once all other variables have been established or clearly defined. The desirability of pursuing this method of approach more fully is realized and additional work in this direction is contemplated.

Mechanism of Ignition:

It is of interest, finally, to conjecture on the possible mechanism by which a rigid plastic specimen ignites.

The ignition point has been taken as that point at which a flame first envelopes the surface of the sample. Two conditions may be extant here and either or both may operate separately or simultaneously. First, it is possible that the actual surface of the plastic is at its ignition temperature and, therefore, burns. Secondly, it is possible that volatile substances and pyrolytic decomposition products are being driven off from the heated material at a rate sufficient to support flame at the surface of the specimen.

In the first case, it will be realized that the surface at the moment of combustion is not the same as when introduced into the furnace. Volatilization, decomposition, and oxidation may have combined to make the material which actually ignites significantly different from that placed in the hot environment. Since the extent of these changes would be a function of the temperature history of the surface, it is expected that the

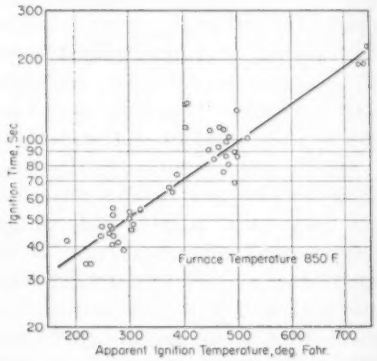


Fig. 9.—Ignition Time versus Ignition Temperature. Furnace temperature, 850 F.

ignition temperature will depend upon furnace conditions.

In the second case, sustained combustion requires that gases be evolved at a rate equal to or exceeding the rate of flame propagation. Furthermore, their initial ignition requires that the surface temperature of the plastic be near the ignition temperature of the gases. (Since in the present experiments an igniter flame is used, the gases may ignite by flash-back to the surface. It is, therefore, not necessary that the surface be actually at the ignition temperature of the gases when

using this device.) The rate of evolution of gases from a plastic sample will depend, at any given moment, on both the temperature history of the sample and the temperature distribution within the sample. Thus, as in the first case, the apparent ignition temperature can be expected to depend on the manner of heating as well as on the nature of the plastic itself.

From the above it would seem that an analysis might be made of the heat-transfer problem as one in unsteady state heat conduction. Such an approach is difficult at best because of lack of information of thermal properties of plastic materials (heat capacity, thermal conductivity, emissivity, etc.). Even if such data were available, a rigorous analysis is virtually impossible in most cases because of physical deformation of the specimen prior to ignition.

It is obvious that there are numerous points in the analysis of the flammability problem which require extensive experimental study, and this paper is offered in the hope of stimulating further investigation.

Acknowledgment:

The authors gratefully acknowledge the encouragement and helpful suggestions of K. O. Beatty, Jr., and the support of the North Carolina State College Department of Engineering Research during the course of this investigation. Thanks are also due to E. B. Cooper, R. C. Boyd, C. R. Stock, F. E. Piech, S. W. Place, F. L. Stiegler, W. A. Zinzow, W. C. Goggin, H. K. Nason, J. H. Teeple, G. E. Vybiral, and others who generously supplied the various samples employed in this work.

References

(1) J. Delmonte and M. A. Azam, "Ignition Points of Plastic Materials," *Modern Plastics*, Vol. 20, pp. 88–89, 1943.

(2) J. A. Gale, R. W. Stewart, and J. B. Alfers, "Flame Resistance of Thermosetting Plastics," ASTM Bulletin, No. 131, December, 1944, p. 23.

(3) I. Hartmann and J. Nagy, "Inflammability and Explosibility of Powders Used in the Plastics Industry," Bureau of Mines, Report of Investigation 3751, May, 1944.

(4) "Fire Hazards of the Plastics Industry," Nat. Board of Fire Underwriters, Research Report No. 1 (1946).

(5) 1946 Modern Plastics Encyclopedia, Plastics Catalog Corp.

(6) E. M. Schoenborn and D. S. Weaver, Jr., "Flammability Characteristics of Plastic Materials. I Surface Temperatures of Rigid Plastics at Ignition," North Carolina State College Research Bulletin, No. 32. To be published.

(7) C. R. Stock, "Fundamentals of Plastics," edited by H. M. Richardson and J. W. Wilson, McGraw-Hill Book Co., Inc., New York, N. Y. (1946). See Chapters XX and XXI, Testing Methods.

(8) W. A. Zinzow, "Flammability of Plastic Sheets and Films," *Modern Plastics*, Vol. 18, p. 59 (1941).

Method for the Determination of Water in Tetrachloroethane, Hexachloroethane, and Chlorinated Paraffin

By L. Wilson Greene[1]

The determination of moisture by distilling the sample with a volatile organic liquid immiscible with water was first proposed by Marcusson (7).[2] Numerous other investigators have developed modifications and improvements in the Marcusson method and have adapted the procedure to a variety of products. The best-known is the method of Dean and Stark (4), who used petroleum naphtha or a mixture of benzene and xylene as the distillation medium. Bidwell and Sterling (3) employed toluene for the same purpose.

The foregoing procedures were based on using a liquid lighter in density than water, and the moisture which separated in the distillation was collected in the bottom of a calibrated glass trap. In 1936, Alexander (1) described a method in which carbon tetrachloride, heavier than water, was employed as the distillation medium for determining water in dynamite. Bailey (2) used tetrachloroethylene and designed a special trap to collect the separated water. An improved trap was proposed by Langeland and Pratt (5), while Lindsay (6) has described recently an ingenious tilt trap for use with perchloroethylene as the distillation medium.

The standard Chemical Corps (formerly Chemical Warfare Service) method of determining moisture by distillation does not seem to have been brought to the general attention of analytical chemists, since no reference to it could be found in the regular literature.

It was first developed to satisfy the need for determining the amount of water present in commercial grades of tetrachloroethane. The Dean and Stark calibrated glass trap could not be employed because it was designed for immiscible liquids lighter than water. Tetrachloroethane is, of course, heavier than water and because of this it was necessary to redesign the trap.

By using anhydrous tetrachloroethane and adding measured quantities of water, it was possible to calibrate the trap and to demonstrate that the method was accurate to 0.01 per cent, when a 1000-g. sample was taken for analysis.

The method has been used satisfactorily for 15 years and it is obvious that, with minor modifications, it could be employed for determining moisture in products similar to the three mentioned above.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Associate Director, Chemical Corps Technical Command, Edgewood Arsenal, Md.

[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

PROCEDURES

Tetrachloroethane (Acetylene Tetrachloride):

(U. S. Army Specification 4-502-12A, August 27, 1942; formerly 4-502-12, September 20, 1933.)

Apparatus.—The apparatus is shown in Fig. 1. The dimensions given should be carefully duplicated to obtain satisfactory results. Flask *A* is a round-bottom, short-neck, 2-liter pyrex flask. The condenser *B* is connected to the apparatus by two short lengths of rubber tubing *G*. The vertical portion of the glass tube above the first length of rubber tube is wrapped with asbestos paper to prevent refluxing. A calcium chloride drying tube is attached to tube *C* to prevent outside moisture from entering the apparatus.

Calibration.—Pour tetrachloroethane in the separator tube *E* until it runs out of the overflow tube into the large flask. Add exactly 2.50 ml. of distilled water from a burette. Measure the height of the water layer in the separator tube. Prepare a measuring scale in which the height is divided into 25 subdivisions, each of which represents 0.1 ml. of water.

Method.—Dry the apparatus carefully before use. Weigh about 900 ml. of sample in an Erlenmeyer flask. Pour the contents of the flask into flask *A* and reweigh the Erlenmeyer flask to determine the weight of sample. Attach flask *A* to the apparatus. Heat rapidly until the boiling point is almost reached and then more slowly as air is being displaced from the apparatus. Boil at a sufficiently rapid rate to carry any separated drops of water downward into the separator tube. Close the latter with a stopper when the water rises to within about ½ in. of the top. Continue the distillation until readings taken at 10-min. intervals show no further increase in the amount of separated water, and the contents of the separator become clear. Using the scale, read the height of the water column and calculate the percentage of water. One division on the scale is equivalent to 0.1 ml. of water.

NOTE.—During the war some suppliers of tetrachloroethane experienced difficulty in procuring the

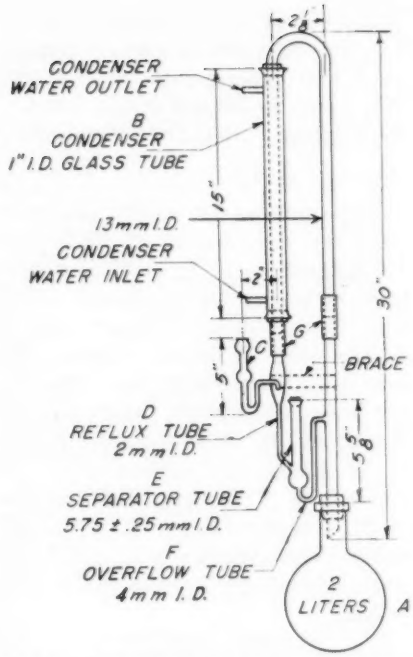


Fig. 1.—Schematic Drawing of Apparatus for Water Determination by the Chemical Corps Method.

apparatus described above. The specification was revised to prescribe the determination of moisture by the cloud-point method instead of by the distillation procedure. Specification JAN-T-247 was issued to cover this revision.

Hexachloroethane:

(Joint Army-Navy Specification JAN-H-235, June 30, 1945; originally U. S. Army Specification 4-503-215, February 17, 1942.)

Apparatus.—Same as above.

Calibration.—Transfer 1000 g. of tetrachloroethane conforming to the requirements of specification JAN-T-247 to flask *A* and distill as described above. Remove the water from separator tube *E* and allow the contents of flask *A* to cool. Add 1.0 ml. of water from a 5-ml. Mohr pipette to flask *A*, stopper the flask, and shake it vigorously. Attach the flask to the apparatus and distill again. When the volume of water in the separator tube shows no further increase, as shown by readings taken at 10-min. intervals, measure the height of the water column in the separator tube. If the recovery of the water introduced is less than 95 per cent, examine the apparatus and procedure for sources of error and then repeat the procedure. Prepare a measuring scale as described under tetrachloroethane, except divide it into 20 subdivisions, each of which represents 0.05 ml. or 0.01 per cent water, when the sample taken is 500 g.

Method.—When flask *A* has cooled, following calibration of the apparatus, remove the water from the separator tube. Weigh approximately 500 g. of the sample and transfer it to flask *A*. Agitate until the sample is completely dissolved in the tetrachloroethane. Attach flask *A* to the apparatus and proceed with the distillation as described in the method for tetrachloroethane. It is not essential to calibrate the apparatus each time, but it is necessary to distill the water from the tetrachloroethane solvent before adding the hexachloroethane, because the solvent normally contains a small amount of water which should be separated first; otherwise the accuracy of the method will be affected.

Chlorinated Paraffin:

(U. S. Army Specification 4-503-127B, April 15, 1944; originally 4-503-127, May 22, 1931.)

Apparatus.—Same as above.

Calibration.—Same as described for tetrachloroethane.

Method.—Weigh about 900 ml. of the sample (approximately 1000 g.) in an Erlenmeyer flask. Rapidly pour the contents of this flask into boiling flask *A* without waiting for the viscous liquid to drain. Reweigh the Erlenmeyer and determine the weight of sample taken for analysis. Agitate until the sample is dissolved and attach flask *A* to the apparatus. Proceed with the distillation as described for tetrachloroethane.

Acknowledgment:

W. F. Still fabricated the original apparatus and contributed valuable suggestions concerning its design. L. S. Dando furnished most of the specification data. Both are employed by the Chemical Corps Technical Command.

REFERENCES

(1) H. B. Alexander, "A New Moisture Tube," *Industrial and Engineering Chemistry*, Anal. Ed., Vol. 8, p. 314 (1936). See also W. W. Scott and N. H. Furman, "Standard Methods of Chemical Analysis," Vol. II, p. 1670, 5th ed., D. Van Nostrand & Co., New York, N. Y. (1939).

(2) A. J. Bailey, "Determination of Moisture in Wood Chips, Sawdust, and Pulp," *Industrial and Engineering Chemistry*, Anal. Ed., Vol. 9, p. 568 (1937).
(3) G. L. Bidwell and W. F. Sterling, "Preliminary Notes on the Direct Determination of Moisture," *Industrial and Engineering Chemistry*, Vol. 17, p. 147 (1925).
(4) E. W. Dean and D. D. Stark, "A Convenient Method for the Determination of Water in Petroleum and Other Organic Emulsions," *Industrial and Engineering Chemistry*, Vol. 12, p. 486 (1920).
(5) E. W. Langeland and R. W. Pratt, "Improved Trap for Moisture Determination by Distillation," *Industrial and Engineering Chemistry*, Anal. Ed., Vol. 10, p. 400 (1938).
(6) W. N. Lindsay, "Distillation Trap for Determining Moisture in Relatively Dry Materials," *Industrial and Engineering Chemistry*, Vol.18, p. 69 (1946).
(7) J. Marcusson, "The Determination of Water in Oils, Fats, and Soaps by Distillation," *Mitt. kgl. Materialprüfungsamt*, Vol. 23, p. 58 (1905).

Discussion of Paper on Lubricants for Synchronous Unit Bearings[1]

MR. FRANK HARDY.[2]—Considerable work was done by the Bell Telephone Laboratories during the war to determine the most suitable lubricants for the ball bearings of synchronous units and other small flea power motors: Our conclusions on the relative merits of different types of lubricants concur to a considerable extent with those of the authors.

Grease lubrication has generally been considered unsatisfactory due to the excessive torque required, especially at low temperatures. However, we should like to point out the possibility of its use, if worked and distributed in the bearings by an initial running-in period of the unit. Experiments in these laboratories indicate that although grease-lubricated bearings require considerably more torque when the grease is first applied than when oil is used, the torque is continually reduced with operation of the unit until values approximate those of oil. These experiments are outlined below:

Motors—3-w., 14-v., d.-c. shunt-wound reversible motors.
Type of Bearings—New Departure 7R3.
Number of Samples—5 motors.
Requirements—Accelerate to 4000 rpm. clockwise or counterclockwise in less than 1 sec. at all temperatures between 120 and −40 F.

Test with Bearings of Five Motors Lubricated with a Synthetic Lubricating Grease:

Time taken to reach 4000 rpm. at −40 F.

(*a*) After one hour's running. Time—from less than 1 sec. to 200 sec.—average, 57 sec.

(*b*) After another hour's running. Time—from less than 1 sec. to 90 sec.—average, 19 sec.

(*c*) After another hour's running. Time—from less than 1 sec. to 8.5 sec.—average, 2.8 sec.

(*d*) After 50 hr. running. Time—all motors accelerated to 4000 rpm. in less than 1 sec.

(*e*) The motors were then allowed to lie idle for 3 months under normal room conditions. Time—all motors accelerated to 4000 rpm. in less than 1 second.

(*f*) The motors were then allowed to lie idle for another month under the same conditions. The motors were then operated in the reverse direction. Time—all motors accelerated to 4000 rpm. in less than 1 sec.

(*g*) After lying idle for another 3 weeks the motors were cycled for 4 days in 90 to 130 F., 95 per cent relative humidity. Time—all motors accelerated to 4000 rpm. in less than 1 sec.

Test with Bearings of Five Motors Lubricated with a Synthetic Lubricating Oil:

(*a*) All motors accelerated to 4000 rpm. in less than 1 sec. at 120 and −40 F.

(*b*) The motors were then operated for 50 hr. and cycled for 4 days in 90 to 130 F., 95 per cent relative humidity. At −40 F. the time taken to accelerate to 4000 rpm. varied from less than 1 sec. to 90 sec.—average, 25 sec.

(*c*) After 1-hr. running. At −40 F. all motors accelerated to 4000 rpm. in less than 1 sec.

Comments:

With synchros and most small ball bearing motors designed as at present with no provision for relubrication, grease lubricated bearings, if satisfactory from a torque standpoint, would probably furnish better service. The greased bearings would be much better protected against corrosion and the entrance of foreign material. However, the best of greases or oils cannot be expected to last for more than from 1 to 3 yr. under service conditions. Lack of proper lubrication is likely to require a major overhaul or discarding of the motor.

It is our feeling that whenever possible, provision should be made for relubrication. Such provision for oil relubrication would probably be simpler and more satisfactory than provision for grease relubrication. Oil relubrication every 6 months or year should give satisfactory protection against corrosion.

Provision for relubrication will be more essential in the future with the expectant life of apparatus extended to many years instead of the short periods expected during the war.

MR. H. GISSER (*author's closure by letter*).—Since this work was reported, additional data have been obtained on grease lubricated synchronous units after 16 months' exposure in the tropics. These data indicate that grease lubrication is promising and lend further weight to Mr. Hardy's data and comments that grease lubrication would probably furnish better service, provided initial torque requirements are met.

The question of provision for relubrication at intervals requires consideration of individual types of equipment. In many instances, the synchronous units constitute component parts of highly complex assemblies and relubrication is not always feasible. With present emphasis on prolonged life of equipment, it is desirable that future developments in this field be along the following lines: redesign of equipment to provide for relubrication when feasible, development of highly stable protective lubricants, and design of bearings from corrosion-resistant materials requiring lubrication only for reducing friction.

[1] Jonathan L. Snead and Henry Gisser, "Lubricants for Synchronous Unit Bearings," ASTM BULLETIN, No. 141, August, 1946, p. 45.
[2] Bell Telephone Labs., Inc., New York, N. Y.

Symposium on Insulating Oil

Editor's Note.—This Symposium, the first of a series of Symposia on Insulating Oil sponsored by Subcommittee IV on Liquid Insulation of A.S.T.M. Committee D-9 on Electrical Insulating Materials, was presented at a meeting held in Atlantic City on October 16, 1946. Other Symposia will follow on appropriate occasions in conjunction with future meetings of Committee D-9 and its subcommittees—the second series of which is being held at the Fiftieth Annual Meeting of the Society.

These symposia are chiefly concerned with the intrinsic qualities of an oil for electrical insulation and a discussion of laboratory tests that will allow accurate appraisal of a new oil or an oil in service with reference to its continued serviceability.

It is generally recognized that certain standardized tests are very useful in appraising an oil but in many cases the accurate correlation of test data to actual performance is yet to be established.

The present Symposium consists of the following four papers:

Steam-Emulsion Number as an Index of Transformer Oil Serviceability—M. D. Baker
The Interfacial Tension Test and Its Significance in Appraising Performance of an Insulating Oil—G. W. Gerell
Application of the Interfacial Tension Test in Grading Transformer Relative to Serviceability—E. F. Walsh
Refresher on Statistical Analysis Applied to Two A.S.T.M. Oil Dielectric Strength Test Procedures—E. W. Greenfeld

The first three papers, together with discussion presented at the meeting, are included in this Bulletin and the fourth paper, that by Mr. Greenfeld, will be included in the August ASTM BULLETIN.

Steam-Emulsion Number as an Index of Transformer Oil Serviceability

By M. D. Baker[1]

It is rather unusual that a member of a committee that has tried for over three years to replace the steam-emulsion test with some method that will determine the emulsifying and demulsifying characteristics of an oil and enable the tester to obtain reproducible results should be asked to defend the steam-emulsion test. The thoughts expressed in this paper are not to be construed as meaning that the present steam-emulsion test cannot be supplanted but rather to illustrate how an emulsion test originally intended for lubricating oils has proved of value in our laboratory when analyzing insulating oils to predict the cause of trouble in equipment. Based upon past experience and the value that can be obtained from this test method, it is thought that the steam-emulsion test should not be dropped until some satisfactory substitute emulsion test has been presented.

The scope of the steam-emulsion test as it is written in A.S.T.M. Standard Method of Test for Steam Emulsion of Lubricating Oils (D 157 – 36)[2] is as follows: "This method is suitable for use on all oils when an emulsion, demulsibility or emulsification test is required. It is commonly used for turbine oils and may be used for other lubricating oils." The method has been approved as American Standard by the American Standards Association, A.S.A. No. Z 11.15-1936 and the American Petroleum Inst., A.P.I. Test No. 515-36.

When used only to determine whether an insulating oil should be continued in service, the steam-emulsion test may not tell anything about an oil that some other test will not tell. When used as a guide to determine what has happened to an oil or to the equipment from which the oil was removed, it can serve as a valuable tool.

The steam-emulsion test to be of greatest value involves more than just recording the number of seconds for demulsification to occur. The person making the test must be trained to observe the type of emulsion formed and how the emulsion separates. Most of the trouble experienced in interpreting the steam-emulsion test when run as just another test and by an unobservant operator can be placed in three classes.

The first class is the emulsion formed with oils that separate rapidly from water. These might be listed as having a zero steam-emulsion number. If an emulsion is formed when making the steam-emulsion test on an oil of this quality it is an oil dispersed in water emulsion rather than water dispersed in oil. This type of emulsion is made when a drop of oil passes over the end of the steam-delivery tube in the clear condensate that has collected in the bottom of the emulsion tube. This type of emulsion results in the formation of a "cuff" of 1 or 2 ml. that persists on top of the water in the emulsion tube and may require hours to demulsify. According to the correct interpretation of the test as it is now written, the steam-emulsion number includes the time required for this emulsion to separate. When this type of an emulsion occurs it can be easily recognized and it should be noted by the tester with some comment that will aid in helping to interpret the test data.

When testing an oil of this classification, that is, when the "cuff" formation occurs, an observation of the emulsion other than the "cuff" should determine the quality of

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Chief Chemist, West Penn Power Co., Pittsburgh, Pa.

[2] 1946 Book of A.S.T.M. Standards, Part III-A, p. 174.

the oil. That is, if a high steam-emulsion number has been recorded due to the time required for the "cuff" to be demulsified, that high steam-emulsion number should not be considered. The rate of demulsibility of the water in oil emulsion should determine the quality of the oil that was tested. The method required to interpret such a condition would be difficult to define and could lead to much controversy.

The second classification is that when demulsification occurs a fibrous network remains in the water although the separation has been sufficient for a steam-emulsion number to be recorded. The network remaining in the water is usually caused by some contamination that has entered the oil. Correlations made between the type of separation that occurs on the steam-emulsion test and available transformer history has given valuable information that has aided in determining questionable causes of trouble in equipment.

The network remaining in the water in the second classification has been used at times to determine the cause of trouble in a transformer. The steam-emulsion number of an oil of this type in conjunction with the power factor test has aided in determining the reasons for transformer failures.

It had been noticed that several oils with high steam-emulsion numbers had been removed from equipment that had experienced bushing trouble. A study made to correlate transformer history with high steam-emulsion numbers showed that bushing compound contamination in the oil always raised the steam-emulsion number. Tests made to determine the effect of two commonly used bushing compounds when mixed in oil gave the following results:

TABLE I.

Bushing Compound, ppm.	Weight, per cent	Steam-Emulsion Number	Power Factor at 25 C., per cent
Original oil		42	0.17
10	0.001	51	0.62
100	0.01	83	3.39
300	0.03		6.33
500	0.05	19 ml. water separated in 600 sec.	10.85
1000	0.1	11 ml. water separated in 600 sec.	16.82
10 000	1.0	1 ml. water separated in 600 sec.	Off scale

Bushing Compound A:

No change was effected on either the neutralization number or dielectric value when adding various amounts of this compound to the oil. The effect of the compound on the steam-emulsion and power factor was positive as shown in Table I.

Bushing Compound B:

This compound was not completely soluble in the oil and the figures given indicate the amount of compound placed in the oil and not the amount dissolved. No change was made on either the neutralization number or dielectric value. The effect of the compound on the steam emulsion and power factor are shown in Table II.

TABLE II.

Bushing Compound, ppm.	Weight Bushing Compound, per cent	Steam-Emulsion Number	Power Factor at 25 C., per cent
Original oil		42	0.17
10	0.001	36	0.23
100	0.01	70	1.02
500	0.05		2.17
1000	0.10	16 ml. water in 600 sec.	3.50
12 500	1.25	1 ml. water in 600 sec.	15.56

At one time when bushing compound contamination in the oil was suspected as a possible cause for a hot transformer, the oil was tested and was found to have a low neutralization number and low steam-emulsion number but a high power factor. The analysis was: neutralization number 0.20, steam emulsion 75, dielectric kv. 31, power factor at 25 C., 23+ per cent. The bushing compound contamination was considered out of the picture and further study was made. The result of this added study was the finding of silica contamination in the oil. The silica had been leeched out from between the laminations in the transformer where it had been used as an insulating compound. The transformer had been in service more than fifteen years before high operating temperatures occurred and caused an investigation to be made. This investigation resulted in finding the silica compound in the oil. After this first experience several other transformers were found to be in similar trouble and a check for silica in the oil resulted in quickly determining the cause and correcting the trouble. Other transformers purchased during the time interval when the silica compound was being used were checked and were found to be operating at higher than normal temperatures.

The third general classification of trouble experienced with the steam-emulsion test is that some oils have the tendency to retain a small amount of water or to form a sludge in the presence of water. The steam-emulsion number may correctly be recorded and be in the low range but the observant operator knows that the separation has not been complete and that there is retained in the oil layer a small amount of water and sludge. This condition quite frequently occurs when testing an oil with a high neutralization number that has been removed from equipment that did not have any water contamination.

The third classification of trouble with interpretation of steam-emulsion numbers requires observing the condition of the oil after the steam-emulsion number has been determined. This observation has aided in predicting the condition of a transformer regarding sludge deposits and the possibility of trouble that might occur due to moisture conditions.

Realizing the factors that should be considered when running the steam-emulsion test and that just a number does not give all the information desired and in lieu of a satisfactory substitute test, it is necessary that the person making the test be properly trained to observe the conditions that exist during the test. The information that can be obtained from the proper interpretation of the test can be used by the engineer in charge of the equipment.

Information can be obtained from an oil analysis that will aid the engineer in determining the cause of trouble in a transformer. These data speed the repair and decrease

outage losses. The single statement that the oil is no good does not go far enough. The correlation of laboratory analyses with service conditions requires cooperation between the electrical engineer and the chemist. This cooperation permits intelligent and valuable use of laboratory oil analyses.

The interfacial tension test has not been made on oils, but in line with verbal and printed statements, there is no doubt that this test would have given information that would have predicted that all oils with a high steam-emulsion number would not be satisfactory for service, but it is doubtful whether that test would have given a clue as to the source of trouble.

It is necessary to repeat that the steam-emulsion test when used for just a number given in an oil analysis is of little value but when the test is made by an observant operator its value is enhanced. As all the operator's notes cannot pass over the desk of the person who decides the program of work on equipment, a test that will give needed information is required. Until this new test has been devised the steam-emulsion test should be used with full realization of its limitations but to the greatest extent of its possibilities.

The Interfacial Tension Test and Its Significance in Appraising Performance of an Insulating Oil

By G. W. Gerell[1]

As far as the utility operator is concerned, transformer insulating oil has two outstanding characteristics that make it of value to him. First, it must have adequate dielectric strength properly to insulate and prevent flashover of the exposed and live parts within the transformer. Second, it must remain in such condition that it will effectively transfer the heat from the transformer windings to the radiating surfaces and this entails its flowing through the core and coil structure and the cooling ducts. To this end it should not sludge and restrict the flow through these same oil ducts. It is this latter characteristic with which we are now concerned. Some years ago the problem was considered by the Union Electric Co. of Missouri and was more specifically stated as a desire to find or develop a simple means whereby the sludging characteristics of power transformer insulating oils in service could be determined. It is true that numerous chemical tests were available which, coupled with an internal inspection of the transformer, left no doubt concerning the state of deterioration of the oil. This procedure, however, was costly and time consuming. An inspection of a transformer to determine whether sludge was present obviously required its removal from service, removal and replacement of some oil, of manhole covers, and so forth, which in turn required the installation of new gasket material and other attendant difficulties. The simple tests that were available at that time consisted of the dielectric and acidity tests, neither of which would tell very much about the sludging tendencies of an oil. In other words, the problem was essentially one that would be solved by any means that would enable an operator to take a sample of oil from the transformer, and by some simple test determine precisely whether the oil was sludging.

With these thoughts in mind several of the research engineers of the Shell Oil Co. were consulted for the specific purpose of determining whether such a test method was available which could be made externally to the transformer. It was essential that the test should reveal a sludging condition within a transformer without the necessity of taking it out of service, lowering its oil, and making a costly internal inspection. The oil company's engineers pointed out that several tests were available to determine the state of deterioration of any organic oil. The hydrophil and saponification numbers, for example, were quite generally recognized as very positive and precise means of determining such condition. Tests of this nature, however, are mainly for the research laboratory. They require proper control and considerable periods of time and were therefore unsuited for routine testing for which we were looking.

It was suggested that possibly the interfacial tension of an oil against water would be a more simple method of measuring the hydrophilic groups in the oil. This test could be done rapidly with a fairly high degree of precision with the DuNouy tensiometer. It should be noted here that interfacial tensions are related to the surface tensions with which most of us are familiar. They are a measure of molecular attractive forces, and differ from true surface tensions in that the attractive forces are between unlike molecules. When the concentration of oxidation products increases in a specific oil sample, the polar molecules at the water-oil interface change their orientation with a corresponding reduction of the interfacial tension.

This suggestion seemed to have considerable merit and a research program was then initiated between the engineers of the Shell Oil Co. and those of the Union Electric Co. in the early part of 1939. The purpose of this program was to test by several methods, including power factor and interfacial tension number, many samples of oil taken from transformers in service on the Union Electric system. If correlation

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] System Relay Engineer, Union Electric Co. of Missouri, St. Louis, Mo.

could be established between a recognized laboratory test and one well adapted for routine field work, it was felt that the problem would be solved.

The preliminary research resulting from this showed that no correlation existed between power factor and the interfacial tension number of used transformer oils. This lack of correlation is undoubtedly caused by the varying moisture content of an oil sample. Since the water content is normally associated with several outside influences, it is not indicative of the state of deterioration of the oil. Therefore, any

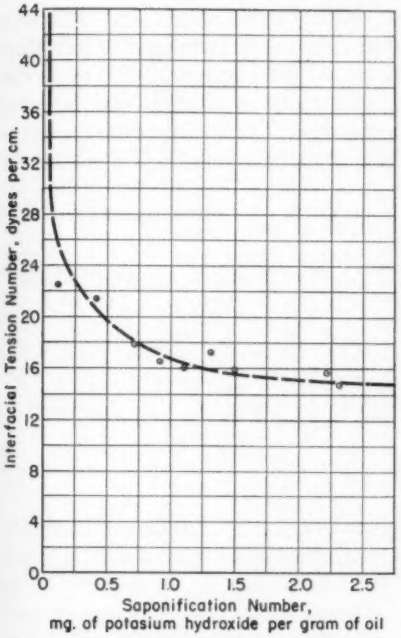


Fig. 1.—The Interfacial Tension Number Correlated with the Saponification Number of Transformer Insulating Oil.

method used to evaluate the condition of used oil should preferably be independent of water content. Measurements made by interfacial tension and saponification number obviously fall into this category. On the other hand, power factor determinations are sensitive to traces of moisture and hence should be made on anhydrous samples if any correlation with such tests as interfacial tension numbers, neutralization number, or saponification value is to be attempted.

Saponification number determinations were, therefore, made according to the A.S.T.M. procedure. Measure of saponification number is generally recognized to be one of

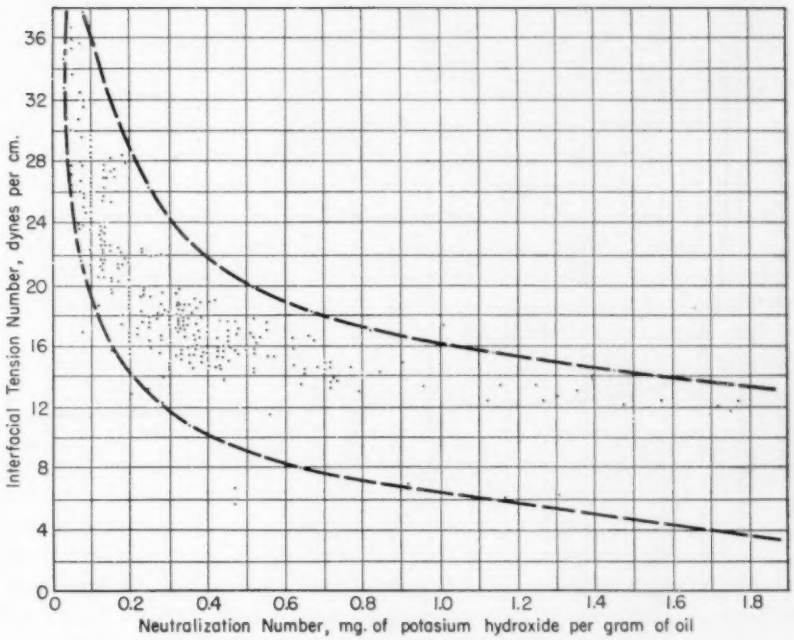


Fig. 2.—Spot Chart Comparing Interfacial Tension Number with the Neutralization Number of Transformer Insulating Oil.

the best tests available for indicating total oxidation products in an oil, for it includes a number of groups including acids plus other materials which can be converted to acids by hydrolysis with alcoholic potassium hydroxide. A very good correlation was found to exist between interfacial tension and saponification number. From this relationship it was observed during the early stages of oxidation that the interfacial tension number fell off rapidly and was therefore an extremely sensitive criterion of such oxidation. As the state of oxidation advances it may be noted from the curve of Fig. 1 that the effect upon interfacial tension decreases and the test becomes less sensitive; however (as will be shown later) there is little doubt that at this point the oil in question is in an unserviceable condition.

With these preliminary investigations completed we adopted in June, 1939, a standard for transformer oil testing. This consisted in making on all samples of transformer oil a series of five tests. These included dielectric breakdown, neutralization number, power factor, the National Petroleum Assn. color number, and interfacial tension number. During the following 3½-yr. period approximately 355 groups of tests on samples of transformer oil in service were accumulated and analyzed. As a result of this analysis we felt that we were justified in drawing certain conclusions concerning the value of these tests.

In Fig. 2 is a spot chart showing the relationship between interfacial tension and neutralization number of several hundred samples of oil. Inspection of this chart showed that it would most certainly require considerable stretching of the imagination to discover any definite mathematical law that might connect the characteristics involved. The variability of the neutralization number of good oils with respect to interfacial tension is somewhat less than for the deteriorated oils. This is to be expected when it is recalled that such oils have several kinds of oxidation products, all of which are not indicated by the neutralization number but are by the interfacial tension number.

In Fig. 3 is shown the relationship between interfacial tension number and power factor. It is immediately apparent that there is a decided lack of correlation. On further examination, however, it will be noted that all of the plotted points lie in an area that can be partially bounded by the dash line shown in the figure. This line or curve does show reasonable correlation between interfacial tension and power factor for those

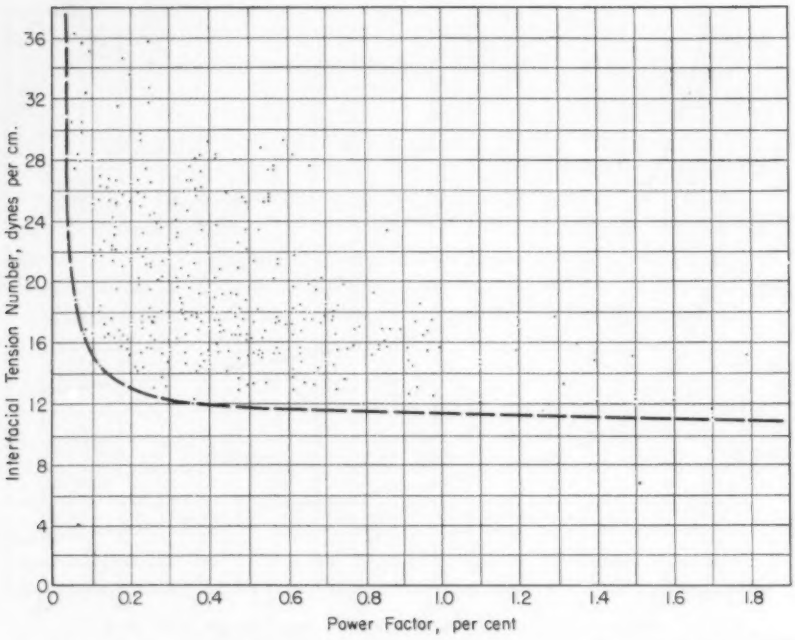


Fig. 3.—Spot Chart Comparing Interfacial Tension Number with the Power Factor of Transformer Insulating Oil.

points lying on the boundary of the area. The reason for this as mentioned in the early part of this discussion is that the power factor of a group of oils having the same interfacial tension number will vary widely with their water content. Those samples within the group having minimum power factor would also have minimum water content. The curve suggests that correlation could be expected if all tests had been taken on an anhydrous sample.

In order to determine the significance of interfacial tension as it may be related to the sludging characteristics of an oil, a number of those transformers tested during the $3\frac{1}{2}$-yr. period referred to were internally inspected and, of course, along with the inspection, the five tests as described previously were made. To present the findings of this study Table I and Fig. 4 are shown. During the course of this study, approximately 124 transformers ranging in size from 1000 to 18,750 kva. were inspected internally for evidences of sludge precipitation. The number of transformers found to be sludging, expressed as a percentage of the total inspected in each specified and limited range of interfacial tension numbers, was then plotted against the mean interfacial tension number of the specific group, producing the curve reproduced in Fig. 4. From this curve it will be noted that all oils having an interfacial tension number below 13 were found to be sludging. All oils having interfacial tension numbers above 21 were found to be free of sludge. Any oil having an interfacial tension number between these two limits is indeterminate in so far as its sludging characteristics may be concerned. However, the curve showing the percentage of transformers found to be sludging is quite precise between these limits. The value of the curve between these limits is, therefore, to give one a factor from which the probability that an oil is sludging may be determined. For example, suppose a particular test on a transformer oil shows the interfacial tension number to be 15 dynes per centimeter. Referring to the curve, it is concluded that in 60 per cent of the cases studied, sludge precipitations would be found. It is quite likely, therefore, that any maintenance crew would decide that it would be worth-while to open the transformer and make an internal inspection. At an interfacial number of 19, however, it is a rather remote possibility that any evidence of sludge would be found and accordingly it would be deemed wise to defer inspection for a period of several years, or until the probability factor reached the point where some assurance of sludging existed.

In January, 1943, the results of

TABLE I.—SUMMARY OF SLUDGING CHARACTERISTICS OF TRANSFORMERS INTERNALLY INSPECTED DECEMBER 15, 1942.

Group Range of Interfacial Tension Numbers	Average Interfacial Tension Number	Number of Transformers Inspected	Number of Transformers Sludging	Percentage of Transformers Sludging
6–8	6.66	5	5	100
10–12	11.46	5	5	100
12–14	13.1	8	8	100
14–16	14.93	31	19	61.3
16–18	17.2	35	10	28.5
18–20	18.9	15	1	6.6
20–22	21.0	14	0	0
22–24	22.5	5	0	0
24–26	25.4	6	0	0

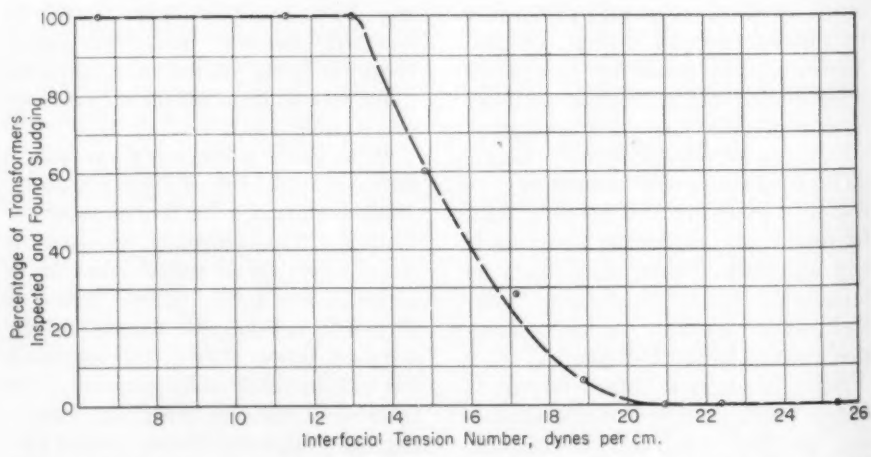


Fig. 4.—Probability of Sludging of Transformer Insulating Oil Correlated with the Interfacial Tension Number.

the investigations discussed herein were presented in a paper by the author to the Doble Engineering Co. Client Conference at Boston, Mass. Since that time many utility companies have adopted the interfacial tension test as one of their tests of transformer oils. Practically without exception, their reports on this form of testing have been quite favorable and indicate that the interfacial tension test is probably one of the simplest and most reliable means of determining the sludging characteristics of transformer insulating oil. As far as our own experience is concerned during these last several years, it is to be observed that upon the completion of the original investigations, we ceased the practice of making internal inspections of all transformers that were tested and relied upon the interfacial tension tests to dictate our maintenance procedure.

The oil tests were usually made along with the annual Doble insulation tests on transformers. The results of all tests were analyzed together in determining whether a transformer should be removed from service and sent to the transformer shop for complete overhaul, including new oil. In general, it was our policy to assume that reconditioning of a transformer was indicated when the interfacial tension number of the oil fell to 15 or less and the winding insulation power factor was high. In this period we removed some 35 to 40 transformers from service for reconditioning. In most cases, the transformers removed from service were ones in which the oil interfacial tension number had attained a value of 15 or less and winding power factor was sufficiently high to indicate that overhaul was necessary. A number of other transformers during this period of time were also taken to the shop for reconditioning, mainly because they were to be moved to a new location and had been in service for many years. The interfacial tension number on this latter group was in no case in excess of 18. When these transformers were inspected it was found that every one of them contained sludge ranging from very light to heavy deposits. It is obvious, of course, that this experience has little bearing on the shape of the curve shown in Fig. 4, with the possible exception that we might consider raising slightly the lower limit of 13.

Finally, it is our conclusion based on some seven years of experience that the interfacial tension test is a very valuable adjunct to some of the more simple and easier tests which are usually made. It is our opinion that it should be considered as one of the standard routine tests to determine the serviceability of transformer insulating oils in service.

[See Joint Discussion p. 99. Ed.]

Application of the Interfacial Tension Test in Grading Oil in Transformers Relative to Serviceability

By E. F. Walsh[1]

The evaluation of the condition of an insulating oil still remains a very difficult problem. There is ever present the question as to whether an oil is sludging or about to sludge, and, as in the case of a new oil, how many hours of service can be expected before sludging occurs.

The routine tests in use generally do not give any indications of conditions until sludging has occurred. The need for a test or tests which will give an indication of deterioration in its early stages has been a subject of investigation for many years. Of the available reproducible tests the power-factor and interfacial-tension tests appear to be the most promising.

The power-factor test is based on the assumption that all dielectrics have some loss, and the measurement of the power factor of an oil, therefore, is a measurement of this loss. It was found that the power factor of an insulating oil is a measure not only of contaminants such as products of oxidation, asphalts, bushing compounds and other oil-soluble contaminants, but also of the moisture present. Its greatest value as a test appears to be as an indicator of the moisture present. Products of oxidation do not appear to have a marked effect on the power-factor value of an oil during the early stages of deterioration; therefore, the test is of little value from that angle. It will, however, indicate the presence of bushing compounds and dissolved insulating varnishes.

The interfacial-tension test has been used experimentally for many years. However, until simplified measuring equipment became available a few years ago, the test was not a practical one. Interfacial tension[2] is a function of certain molecular groups present in an oil and bears a relation to its emulsifying tendencies. The polar molecules (soaps, acids, etc.) concentrate at the oil-water interface and orient themselves with the carboxyl groups toward the water phase. In the early stage of oxidation, these impurities begin to form in minute quantities. Because these impurities concentrate at the oil-water interface, the logical procedure would be to determine the interfacial tension of the two liquids.

The interfacial tension is the only known practical method of measuring the deterioration of mineral oils during its nonsludging life, especially oils fortified with oxidation inhibitors.

This paper deals primarily with the results of a study of power-factor and interfacial-tension tests

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Assistant to Superintendent of Power Plants, The Narragansett Electric Co., Providence, R. I.

[2] G. H. Von Fuchs, N. B. Wilson, and K. R. Edlund, "Evaluation and Performance of Turbine Oils," *Industrial and Engineering Chemistry*, Vol. 13, p. 306 (1941).

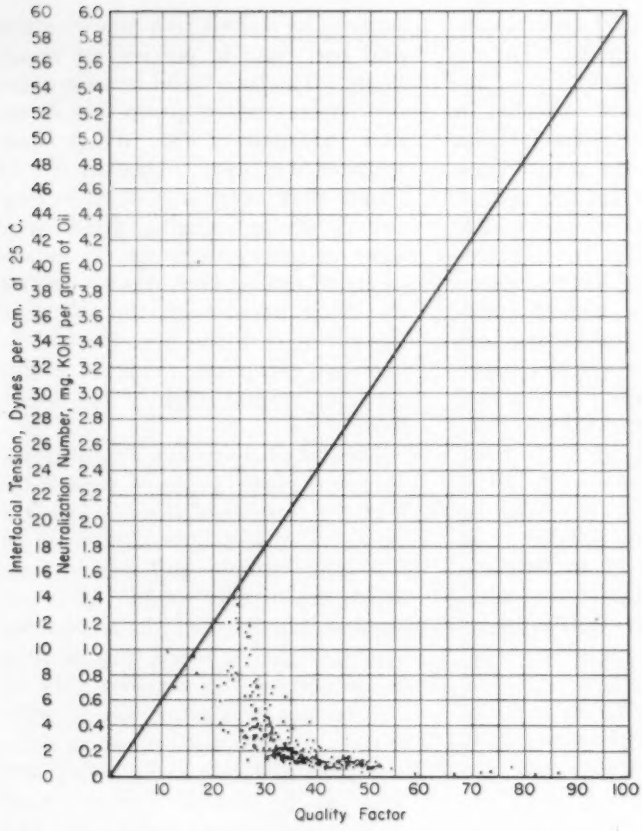


Fig. 1.—Relation of Neutralization Number to Interfacial Tension Value versus Quality Factor.

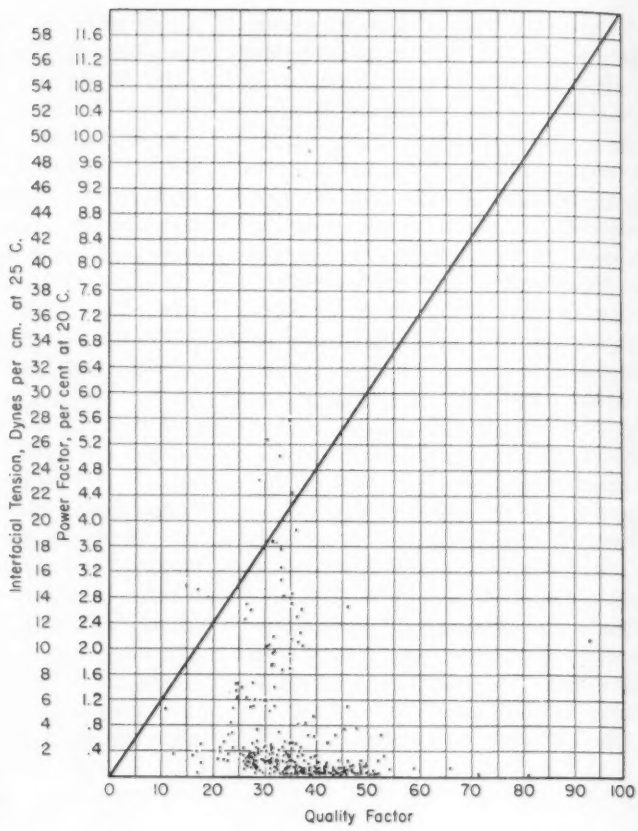


Fig. 2.—Relation of Power Factor to Interfacial Tension Value versus Quality Factor.

as they apply to insulating oils. Satisfactory correlation of these tests with other tests may be possible, but would be of little value in predicting the condition of an oil. It appeared that if these data were correlated with a factor significant of oil quality, a factor could be devised that could be used directly to predict the condition or life of an insulating oil. This factor could then be developed to be the composite of one or more tests, leaving the responsibility of interpretation to those familiar with the limitations of the various test values.

The term selected for this concept was "Quality Factor" having a range of 0 to 100, zero being oil no longer serviceable and 100 being oil in excellent condition. The first correlation attempted was with neutralization number and interfacial tension with quality factor. Several hundred samples of oil were analyzed from equipment in which the physical conditions were known. The purpose of this correlation was to determine if possible the value of neutralization number in predicting the condition of an insulating oil. The procedure was as follows (Fig. 1):

Quality factor was designated as the abscissa with uniformly graduated horizontal axis (values 0 to 100) with positive direction running to the right. Interfacial tension and neutralization number were designated as the ordinates with values 0 to 60 and 0 to 6, respectively. A tangent was then drawn from the intersection of the abscissae and ordinates to the intersection of the interfacial-tension value of 60 and quality factor of 100. An interfacial-tension value of 60 was chosen as representing an ideal oil—an ultimate value that is not yet obtainable.

Interfacial tension and neutralization numbers were then plotted as follows: The interfacial-tension value of the oil was found on the ordinate and projected on a horizontal axis to the intersection of the tangent. At this intersection and on a perpendicular axis the neutralization-number value was found and plotted.

If we assume that interfacial tension indicates contaminants such as soaps, acids, etc., as investigations to date imply, this graph shows that neutralization number is of little value in determining the condition or the progress of deterioration of an insulating oil until it has about reached or has reached the sludging stage. Many transformers having oil with a neutralization number between 0.1 and 0.2 mg. have been found to have sludge or varnish deposits on core and windings.

A similar correlation was made with power factor, interfacial tension, and quality factor (Fig. 2). This correlation indicates that in general there is no appreciable increase in power factor value with decrease in oil quality in the quality factor range of 40 to 100. Oils having a quality-factor value of less than 40 may have a power factor of almost any value. It was found that with oils known not to have reached a sludging condition, a good correlation between power factor and quality factor is obtainable after filtering the oil to remove free moisture (above the saturation value of oil at the temperature at time of filtration). This indicates that

power factor is a measure of the moisture present in a serviceable insulating oil.

The spark test as now used to indicate moisture in oil is not entirely satisfactory and is the subject of much controversy. Whereas the spark test indicates the condition of that portion of the sample between the disks, the power factor measures the average of the entire sample.

It is recognized that the presence of moisture in insulating oil is undesirable for several reasons. Most acidic oxidation products, as they form, are soluble in water, and the water then becomes acidic and is absorbed by the insulation resulting in lowering its dielectric strength. The presence of water in oil also acts as a catalyst in the presence of copper and iron to form metallic soaps, thus accelerating oxidation.

It is then to our advantage to maintain insulating oil as free from moisture as is practical. Insulating oil can hold in solution or finely

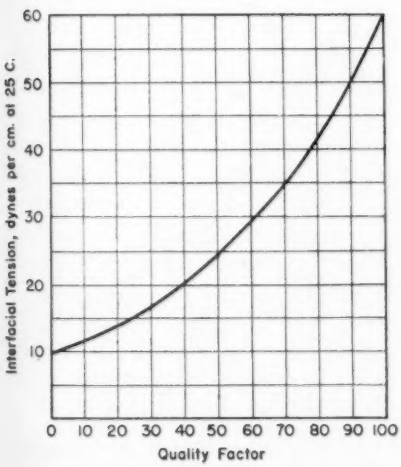


Fig. 3.—Determination of Quality Factor.

To determine quality factor:

1. Determine interfacial tension value of oil.
2. Find interfacial tension value of oil on scale marked Interfacial Tension.
3. Project this point horizontally to intersection of Quality-Interfacial Tension Line, then downward to scale marked Quality Factor. Value indicated is quality factor.

NOTE.—The quality factor at present does not take into account the moisture content of an oil. The dielectric strength of an oil must be maintained according to present standards.

For the present, quality factor, power factor, and dielectric strength shall be used to determine the condition of an insulating oil.

1. If the quality factor is above 34 and the power factor less than 2 per cent, insulating oil can be considered satisfactory for continued use.
2. If the quality factor is above 34 and the power factor is 2 per cent or greater, the oil should be filtered. It will then be satisfactory for continued use.
3. If the quality factor is less than 34, the oil has deteriorated where sludge or varnish will deposit on windings. Oil in this condition should be changed.

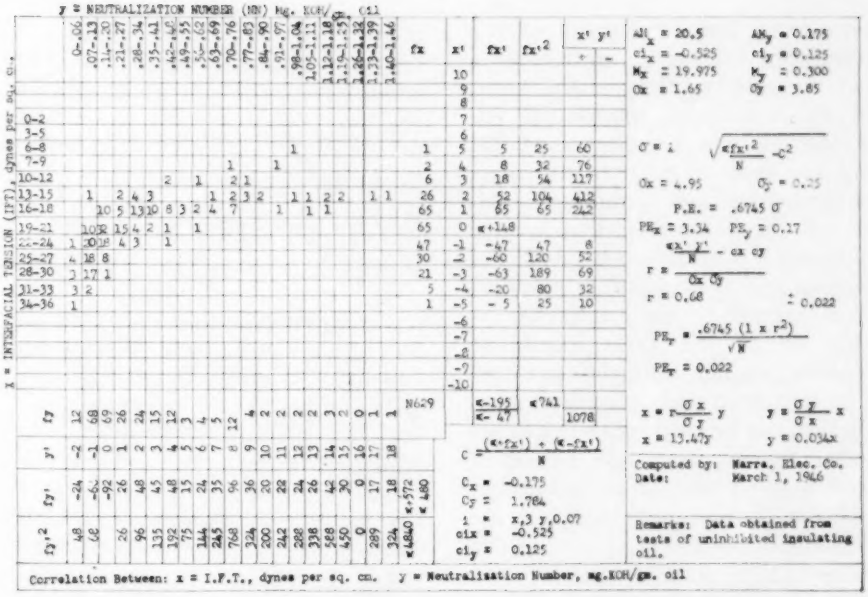

y = NEUTRALIZATION NUMBER (NN) Mg. KOH/
X = INTERFACIAL TENSION (IFT) dynes per sq.
Correlation Between: x = I.F.T., dynes per sq. cm. y = Neutralisation Number, mg.KOH/gm. oil
Remarks: Data obtained from tests of uninhibited insulating oil.
Computed by: Harra. Elec. Co.
Date: March 1, 1946

Fig. 4.—Correlation Between Interfacial Tension and Neutralization Number.

divided in suspension from 15 to 300 ppm., the amount depending upon the stage of deterioration. Thus, we find that the moisture content is related to oil quality.

From these data presented, an experimental control graph was made (Fig. 3) involving two factors, namely, interfacial tension and power factor, to predict the quality or condition of an insulating oil.

The procedure is to determine the interfacial-tension value and power factor of the oil in question. Reference is then made to the graph and the quality factor determined. The quality factor in this case does not include the moisture content, so it is necessary to know the power-factor value of the oil. In developing the graphs it was found that, from case histories, oil having a quality factor below 34 had a sludging tendency, and that, as previously mentioned, power-factor values increased with moisture content. The following rules were decided upon for the trial period to indicate the quality of an oil:

1. If the quality factor is above 34 and the power factor less than 2 per cent, insulating oil can be considered satisfactory for continued use.

2. If the quality factor is above 34 and the power factor is 2 per cent or greater, the oil should be filtered or centrifuged. The oil will then be satisfactory for continued use.

3. If the quality factor is less than 34, the oil has deteriorated to a point where sludge or varnish is likely to deposit on core and windings. Oil in this condition cannot be corrected by filtering and should be changed.

A study of interfacial tension, neutralization number, and power factor values of uninhibited insulating oils suggested the calculation of correlation coefficients by the product-moment method between each two of the three tests. This method is described in most textbooks on statistics and is illustrated on the accompanying scattergram (Fig. 4) and calculations of the correlation between interfacial tension and neutralization number. This was the only correlation considered high enough to be significant, as the coefficient of linear correlation between interfacial tension and power factor was 0.13 with a probable error of ±0.03, and that between neutralization number and power factor was 0.03 with a probable error of ±0.04.

The mean of the interfacial tensions is 19.975 dynes per square centimeter for the 269 cases considered, while the mean neutralization number is 0.300 mg. KOH per gram of oil for the same number of cases.

Use of regression equations indicates that a deviation of ±1.0 from the mean of the neutralization numbers is accompanied by a deviation of ±13.47 dynes per square

centimeter from the mean of the interfacial tensions; conversely a deviation of ±1.0 from the mean of the interfacial tensions is accompanied by a deviation of ±0.034 mg. per gram of oil from the mean of the neutralization numbers. Although regression equations involve both x and y (in this case interfacial tension and neutralization number) they cannot be used interchangeably to predict both interfacial tension and neutralization number. The first regression equation, $x = 13.47\,y$, can be used *only* when interfacial tension is to be predicted from a given neutralization number (when x, or interfacial tension is the dependent variable); while the second, $y = 0.034\,x$ can be used only when neutralization number is to be predicted from a given interfacial tension.

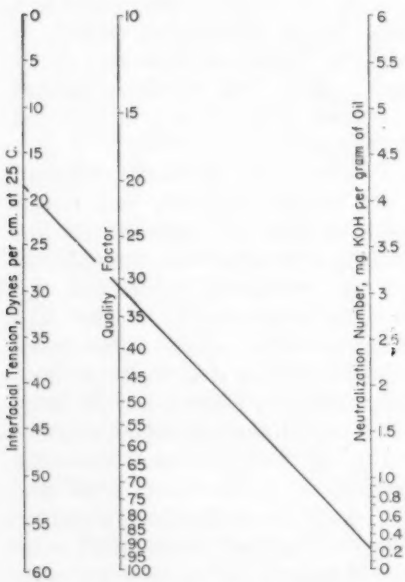


Fig. 5.—Chart for the Evaluation of Insulating Oils.

In order to avoid working through the means, use of the regression equations will probably be more convenient if they are put in score form as follows:

X (Actual interfacial tension score) =

$$r\frac{\sigma x}{\sigma y}(Y - M_y) + Mx$$

or actual interfacial tension score =

$$13.47\overline{Y} + 15.63$$

where

$\overline{Y}$ = actual neutralization number score

Similarly,

$\overline{Y}$ (actual neutralization number score) =

$$r\frac{\sigma y}{\sigma x}(X - M_x) + M_y$$

or actual neutralization number score =

$$0.034\ X - 0.379$$

where

X = actual interfacial tension score

Also

M_y = mean neutralization number and
Mx = mean interfacial tension

The regression equations should not be used when *both* interfacial tension and neutralization number are determined or given.

The accompanying nomograph (Fig. 5) was constructed by choosing arbitrary limits for interfacial tension and neutralization number, making the two scales inversely proportional and placing the logarithmic quality factor scale in such a position as to weigh the interfacial tension reading to vary directly as the ratios of the sigmas (standard variations) from the means of the two tests.

$$\frac{M_x}{\sigma x} = \frac{19.975}{4.95} = 4.04 \qquad \frac{M_y}{\sigma y} = \frac{0.30}{0.25} = 1.2$$

$$\frac{4.04}{1.2} = 3.7$$

which is the proportional distance of the quality factor scale between the other two.

From the average increases in neutralization number in new or reconditioned uninhibited insulating oil over varying periods up to seven years an empirical formula was derived for predicting the neutralization number in a given number of months.

Future neutralization number

$$\left(\frac{\text{number of months}}{40} \times 0.1\right) + \text{present neutralization number}$$

For example, an uninhibited insulating oil having a neutralization number of 0.07 will probably in normal service after 20 months have a neutralization number of $20/40 \times 0.01 + 0.07$ or 0.12 mg. per gram. This equation will not hold for all individual cases, but shows merely the average trend of most oils.

Further development in the use of the tests referred to which are considered indicative of an oil's quality suggest an alignment chart (Fig. 6) which incorporates interfacial tension, power factor, and moisture values—all referred to quality factor. This method of evaluating insulating oil removes the possibility of different interpretations of the values of individual tests. Data collected and studied to date indicate that such an alignment chart is possible. At least a year will be necessary before sufficient case histories can be studied and oil samples analyzed to develop a usable alignment chart as indicated.

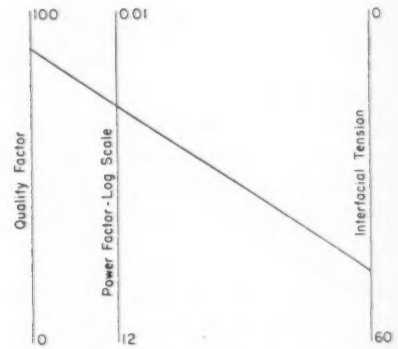


Fig. 6.—Alignment Chart Incorporating Interfacial Tension, Power Factor, and Moisture Values for the Determination of Quality Factor.

The data and expressions of ideas contained in this paper are to be considered for information purposes only and are not to be construed as workable data.

MR. E. M. KIPP.[1]—With respect to the use of oil-water-interfacial tension values in determining oil quality, our company has been giving this matter considerable attention for a period of several years. As a result of these investigations, the interfacial tension test was made a part of the company's standard power system oil maintenance program. We are of the opinion that the interfacial tension value is the most reliable and most meaningful single oil test available for determining the quality of the oil at the time of measurement.

In the papers by Messrs. Walsh and Gerell, it was indicated that on the basis of many field measurements, all oils having interfacial tension numbers above 21 were found to be free of sludge, whereas all oils having interfacial tension values below 13 were found to be sludging. It was also indicated that, in general, a safe minimum value would be an interfacial tension number of 17 or 18, and that sludging would not be likely to be present if the oil possesses an interfacial tension value of above 17 or 18.

With reference to the practical utilization of the excellent information contained in the papers presented by Messrs. Walsh and Gerell, we should like to call attention to a detail with regard to maintenance programs which should be considered in attempting to apply interfacial tension values in the maintenance of power system oils. In many cases transformers are operated for rather long periods of time and the oil allowed to deteriorate to the place where remedial maintenance is required. However, other companies such as our own, for example, have adopted or are adopting a system of continuous preventive maintenance of the insulating oils through the use of thermosiphons. These thermosiphons filled with adsorbents of various types in effect continuously by-pass filter the insulating oil, thus for all practical purposes providing continuous preventive oil maintenance.

Considerable data have been obtained on a laboratory scale indicating that the connection between the interfacial tension value and the sludging point of an insulating oil can be very markedly affected by continuous by-pass filtration through an adsorbent. As a specific example, a large number of accelerated oxidation tests have been carried out with a representative commercial insulating oil in an A.S.T.M. oil oxidation unit and the sludging point was found to occur always at an interfacial tension value of from 16 to 18. When a portion of this same oil was by-passed through adsorbent A during the oxidation, the sludging point of the oil likewise occurred at an interfacial tension value of from 16 to 18. However, when adsorbent B was substituted for adsorbent A, the destructive oxidation of the oil was continued until the interfacial tension of the oil reached a value of 10, with absolutely no evidences of sludge formation even after prolonged standing and cooling of the oil. This, then, would suggest that in those cases where insulating oils are continuously by-pass filtered through activated adsorbents, the data developed by Messrs. Walsh and Gerell with regard to the significance of interfacial tension values and sludge points of oils may not necessarily apply without some modification.

MR. WILLIAM G. HORSCH.[2]—Since I have had an opportunity to read Mr. Walsh's paper in more detail than was possible during the meeting, I feel that the text portion would be helped by clarification and by amplification beyond what was brought out in the discussion. For example, the author's statement (paragraph 5): "interfacial tension is the only known practical method of measuring the deterioration—during its nonsludging life—" is quite broad and subject to considerable question. Also the use of the word "quality" apparently as synonymous with "condition" is likely to be misleading. Although reference is made to sludging in the text, no sludging data or sludging times are presented. Apparently the author realizes these deficiencies since he states at the end that the data are "for information only and are not to be construed as workable data."

The author states (paragraph 3) that "Products of oxidation do not appear to have a marked effect on the power factor value of an oil during the early stages of deterioration." How is this statement reconciled with the observed facts that in a relatively short-time laboratory oxidation test in which no contamination occurs there is such a marked rise in power factor?

If Rule 3 on page 97 were consistently followed, a lot of good oil might be needlessly changed.

Probably the big difficulty in the use of either power factor or interfacial tension is the fact that each one is affected by contamination as well as by the deterioration caused by oxidation. This tends to render the indications of these two quantities ambiguous.

The results of a few experiments that we have carried out may be of interest in connection with Mr. Gerell's paper. In a controlled test, four small transformers were filled with portions of the identical new commercial transformer oil. These were operated under the same set of conditions except that in one pair the lids were raised so that the oil was freely exposed to the air while in the other pair the air was displaced with nitrogen and the lids bolted down tight. Loading was by a feeding-back connection at rated voltage and somewhat above rated current. Top-oil temperature was held constant at 85 C. After three years the following observations were made:

Condition	Neutralization Number of Oil	Interfacial Tension of Oil	Sludge Deposit in Transformer
Open	0.64	13.6	Present
Open	0.57	14.7	Present
Nitrogen (Sealed)	0.15	15.0	Absent
Nitrogen (Sealed)	0.15	15.7	Absent

The small neutralization number in the oil under nitrogen apparently was due to material absorbed from the transformer. These results are not necessarily inconsistent with the data presented by Mr. Gerell.

[1] Assistant Chief, Physical Chemistry Div., In Charge, Oils and Lubricants Section, Aluminum Research Laboratories, Aluminum Company of America, New Kensington, Pa.

[2] Research Department, Socony Vacuum Oil Co., Paulsboro, N. J.

However, they indicate that interfacial tension values by themselves cannot be taken as a unique or infallible sign that a transformer is or is not sludging.

MR. C. L. POPE.[3]—I should like to ask Mr. Walsh a question. Does following the interfacial tension of a transformer oil indicate the trend. In other words, if the interfacial tension drops over a period of time in a given transformer can one predict that it will continue to drop at about the same rate.

MR. E. F. WALSH (*author*).—The deterioration of an insulating oil in a transformer can be followed by determining the interfacial tension value of an oil periodically and correlating the values with time. We have prepared such records for all of our power transformers.

Present indications are that these data will be helpful in setting up extended maintenance schedules.

MR. POPE.—It is the writer's opinion that then we must assume that the breakdown pattern of all insulating oils follows a definite pattern. In industrial oils containing principally oxidation inhibitors, it has been found advantageous to run an accelerated oxidation test so that the breakdown pattern of a given oil can be found so as to evaluate the analysis received from the field. This might be profitably applied to insulating oils.

Mr. Walsh on page 97 of his report mentioned, under item 2, that filtering or centrifuging could be used to restore the oil. Would he care to give us a before and after filtering analysis together with any data that he may have as to how the reconditioned oil compared with new oil in service? In filtering, does he deem it sufficient to mechanically remove dirt, water, etc., or does he believe it necessary to use a chemical treatment such as a selective type of clay?

MR. A. J. REVUKAS.[4]—I have the following questions for both Messrs. Gerell and Walsh:

1. Has consideration been given to the presence of antioxidant or antisludging additives which might possess surface activity in insulating oil?

2. Have interfacial tension studies been considered with synthetic insulating oils, particularly the halogenated aromatic bicyclic types?

Presumably not only the technique for evaluation under either of the aforementioned conditions but also the currently employed values 13 to 16 dynes for renewing a transformer oil would require modification.

MR. WALSH.—The data presented included oils containing antioxidants as well as uninhibited oils. Extensive tests have been made on oils containing antioxidants during approximately 12 years operating life to date. Although the change in neutralization number of these oils has been negligible, it has been possible to follow the rate of deterioration by determining the interfacial tension values. In actual practice oxidation inhibited oils have not yet reached a stage of deterioration where sludge is depositing, therefore, the neutralization number is of little value in predicting the condition of the oil.

Interfacial tension studies have been considered with synthetic insulating oils, but no experimental work has been done. Oxidation tests on oxidation inhibited oils follow the same general law as uninhibited oils. That is, sludging occurs at the same interfacial tension value—normally about 18 dynes.

MR. E. R. THOMAS.[5]—In Mr. Walsh's paper, did the data collected by the Narragansett Electric Co. cover both open breather type transformers and transformers which maintain an inert gas above the oil? If the data included both types, were there any differences in correlation between interfacial tensions and oil power factor and between interfacial tension and neutralization number for these two different types of transformers?

MR. WALSH.—The data collected represented transformers of the open breather, conservator, and inert gas types. We were unable to detect any difference in correlation between interfacial tension and power factor and between interfacial tension and neutralization number for these types of transformers.

[3] Lubrication Engineering, Eastman Kodak Co., Rochester, N. Y.

[4] Research Laboratory, Bayonne Refinery, Tide-Associated Oilwater Company, Bayonne, N. J.

[5] Test Engineer, Electrical Engineering Dept., Consolidated Edison Co. of New York, New York, N. Y.

INDEX TO ADVERTISERS

American Beam Tester Co. 103
Andrew Technical Service 108
Angel & Co., Inc., H. Reeve 116
Ansco 105
Applied Research Laboratories 119
Atlas Electric Devices Co. 118
Baldwin Locomotive Works ..... Inside Front Cover
Bausch & Lomb Optical Co. 103
Boder Scientific Co. 3
Bowser, Inc. 102
Buehler, Ltd. 120
Burrell Technical Supply Co. 111
Carver Inc., Fred S. 107
Central Scientific Co. 114
Corning Glass Works 109
Eastman Kodak Co. ..... Inside Back Cover
Eimer & Amend, Inc. 106
Fisher Scientific Co. 106
General Radio Co. 2
Greiner Co., The Emil 112
Hanovia Chemical & Mfg. Co. 112
Kimble Glass Co. 117
King Refrigeration Co. 110
Leeds & Northrup Co. 4
Link Engineering Co. 102
Morehouse Machine Co. 104
New York Laboratory Supply Co. 118
Olsen Testing Machine Co., Tinius ..... Outside Back Cover
Parr Instrument Co. 108
Perkins & Son Co., B. F. 103
Precision Scientific Co. 113
Rainhart Co. 104
Remmey Son Co., Richard C. 106
Sargent & Co., E. H. 110
Scott Testers, Inc. 102
Thomas Co., Arthur H. 116
Thwing-Albert Instrument Co. 103
Will Corporation 115
Wilson Mechanical Instrument Co., Inc. 102
Professional Cards 101